HISTORICAL FIRE REGIMES OF THE UPPER GREAT LAKES REGION: FROM PEATLANDS TO PINES

by

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Dedicated to my parents, Mark and Gail, who instilled in me a tenacity to overcome anything life throws my way. I wish I could share this with you both.

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Introduction

The upper Great Lakes Region is ecologically diverse supporting 60 million people and more than 3500 plant and animal species (Kling et al. 2003). Rapid climate and land use changes are among the greatest threats to the diverse ecosystems of the upper Great Lakes Region. Since 1951, climatic changes across the upper Great Lakes have resulted in average annual air temperatures increasing by 1.3°C, total annual precipitation increasing by 13.6%, and heavy precipitation events increasing by 35% (ECCC and NOAA 2020). In addition to rapid climate change, land use change across the upper Great Lakes Region has been extensive, most notably from the mid-19th century to the early 20th century. During this period, approximately 20 million hectares of forests were logged (Williams 1992) and more than half of all wetlands were lost mostly due to rapid conversion into agricultural lands (Fretwell et al. 1996).

Significant land use changes after European settlement resulted in homogenization of landscapes across the upper Great Lakes Region (Frelich 1995; Schulte et al. 2007; Goring et al. 2016) and without historical context it is unknown how projected climate change and climate variability will influence the severity and frequency of disturbances across the upper Great Lakes Region (Pryor 2013; Sturrock et al. 2011; Easterling et al. 2017). Ecosystem resilience, or the capacity of an ecosystem to recover after disturbance, is maintained over centuries as adaptations develop under disturbance regimes and resilience erodes when disturbance regimes are outside of the historical range of variability (Johnstone et al. 2016). Disturbance regime characteristics (e.g., frequency, extent, severity) in conjunction with climate, topography, vegetative structure, and species composition, contribute to highly complex and regionally variable disturbance regimes (Wein et al. 1983, Zoltai et al. 1998).

Fire was one of the most ubiquitous disturbances across the upper Great Lakes Region prior to European settlement (Whitney 1986, Schulte and Mladenoff 2005). However, due to a paucity of data related to historical fire regimes, the historical range of variability in fire regimes among diverse ecosystems of the upper Great Lakes Region is poorly understood (Heinselman 1963, 1973, Bergeron et al. 2004). Fire regimes across the upper Great Lakes Region have generally been reconstructed with sediment records (Booth and Jackson 2003, Booth et al. 2004) or settlement surveyor data (Whitney 1986, Cleland et al. 2004, Schulte and Mladenoff 2005). These methods are best suited for understanding high-severity fires that burned across large regions of continuous fuels (Cyr et al. 2007, Kelly et al. 2013). Dendrochronology approaches can reconstruct frequent low-severity surface fires that are largely missed in sediment charcoal records and settlement surveyor data (Higuera et al. 2011, Remy et al. 2018). Reconstructing historical disturbance regimes across multiple spatial scales, among diverse ecosystems, and over continuous temporal records provides the best evidence of historical ranges in variability (Schulte and Mladenoff 2005; Falk et al. 2011; Swetnam et al. 2016).

We built an extensive fire-scar network across the upper Great Lakes Region among diverse ecosystems to reconstruct historical fire regimes and provide evidence of historical ranges of variability in fire regimes across the region. Fire-scar networks provide crucial reference information for identifying altered fire regimes (Falk et al. 2011) and provide evidence of regionally significant fire years that are driven by climate and land use change (Swetnam and Betancourt 1990; Grissino-Mayer and Swetnam 2000; Brown et al. 2001).

In chapter one, we reconstructed historical fire regimes of peatlands in the upper Great Lakes Region prior to European settlement to evaluate (1) low- to moderate-severity fire frequencies for fire events; (2) synchrony of widespread fire events among forested uplands within and surrounding peatlands; and (3) climate-fire relationships. We reconstructed fire regimes in peatlands at finer spatial and temporal scales with fire-scarred trees and detected frequent low-severity fire events which have been overlooked in peatland fire ecology in the upper Great Lakes Region (Cleland et al. 2004; Booth et al. 2004; Dickmann and Cleland 2005). Our results indicated that low-severity fire events were frequent (7–31 year mean fire return intervals), widespread, did not occur during severe regional drought, and were an important component of hemiboreal peatland fire regimes. Species composition, peatland surface fuel patterning, variability in ignition sources, and localized drying likely maintained historical fire regimes in peatlands of the upper Great Lakes Region. Altered fire regimes in peatlands of the upper Great Lakes Region, related to both increasingly severe fires driven by climate change and suppression of low-severity fire, may destabilize peatland ecosystems making them more vulnerable to climate change and future disturbances (Flanagan et al. 2020).

In chapter two, we used an extensive fire-scar network across the upper Great Lakes Region and evaluated variability in historical fire regimes across disparate ecoregions by (1) estimating fire frequency; (2) detecting widespread fire years and regionally significant fire years; and (3) identifying regional climate-fire relationships. Historically, small fires were frequent (3–17 years) and widespread fires were less frequent (17–45 years) across the upper Great Lakes Region. Variability in fire frequency among ecoregions was likely driven by temporal and spatial variations in vegetation, ignition sources, physiography, weather, and barriers to fire spread (Falk et al. 2011). Climate synchronized fire activity at regional scales resulting in widespread fire years (1689, 1752, 1754, 1791, and 1891) during significantly dry periods through the upper Great Lakes Region. Frequent low-severity fires and climate driven widespread fires were key components of historical fire regimes among ecoregions across the upper Great Lakes Region. Fire suppression since the early 20th century has effectively excluded fires in the region, but the potential for widespread climate driven fire events remains, especially with potential changes in climate variability in the region including severe summer droughts and frequent heavy rain events.

We found that historical disturbance regimes across the upper Great Lake Region were characterized by frequent, low severity, and widespread fires. The use of prescribed low-severity fire across the upper Great Lakes Region is supported and could contribute to the persistence of ecosystems including poor fens and mixed-pine forests but may not be a viable management solution for all ecosystems, especially those which have significantly departed from historical conditions. Investigating the impact of altered disturbance regimes on ecosystem processes and patterns is paramount in assessing the vulnerability of diverse ecosystems of the upper Great Lakes Region to continued climate change, land use changes, and novel disturbances. Extensive networks that include tree-ring, sediment, and historical records establish historical ranges of variability in disturbance regimes within and among ecosystems revealing the influence of broad scale drivers on fire regimes. Integrating these records with predictive models will provide the best insights to the capacity of ecosystems to recover and persist under broad scale, highly variable climate changes.

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Chapter 1. Historical fire regimes of North American hemiboreal peatlands

Abstract

Peatlands contain one-third to one-half of global soil carbon, and disturbances, specifically fire, directly influence these carbon stocks. Despite this, historical variability of peatland fire regimes is largely unknown. This gap in knowledge partly stems from reconstructions of peatland fire regimes with methods limited to evaluating infrequent, severe fire events and not capturing frequent, low-severity events. Furthermore, variability in fire regimes is likely higher in heterogenous landscapes like the hemiboreal subzone, the transition between boreal and temperate biomes, where peatlands are embedded in landscapes including forests with high proportions of fire-dependent species, such as red pine (*Pinus resinosa*), that are well adapted to frequent low-severity fires. Here, we sought to evaluate the role of low- and moderate-severity fires within hemiboreal peatlands in central North America to better understand historical variability in fire regimes. We reconstructed historical fire regimes using fine-scale (temporal and spatial) dendrochronology methods to estimate frequency of low- and moderate-severity fires, identify synchronous fire events among forested uplands within and surrounding individual peatlands as well as among sites, and assess fire-climate relationships. We collected 220 cross-sections or partial-tree sections within three poor fen peatlands across the Great Lakes Region. Using standard dendrochronological techniques, we crossdated 129 samples, assigning dates to 414 fire scars (128 unique fire years) comprising a 500-year tree-ring record (1520–2019). Prior to the mid-1900s, fire events were frequent and widespread within peatlands we evaluated, with mean

fire return intervals (MFRI) ranging from 7–31 years. Fire events were also synchronous among forested uplands within and surrounding peatlands. Fires predominantly occurred in the dormant and latewood (growing season) positions and during regionally dry conditions corresponding to mild and moderate drought (Palmer Drought Severity Index $\geq$ -2.99) but interestingly not during regionally severe drought (Palmer Drought Severity Index $\leq$ -3.00). While large-scale, high-severity fires are important to the ecology of peatlands and to changing climate-fire interactions, our results suggest that widespread low- to moderate-severity fires were historically frequent in hemiboreal peatlands and likely central to their development and maintenance. Evaluating whether peatlands will continue to be carbon sinks or become carbon sources due to climate change requires an understanding of the inherent variability in fire regimes, especially in hemiboreal systems.

Introduction

Peatlands are waterlogged organically enriched wetlands that cover 3% of Earth's land area and provide a high proportion of global ecosystem services (Rydin *et al.* 2013), including climate regulation through carbon sequestration and storage (32–46% of global soil carbon; Bonn and British Ecological Society 2016, Page and Hooijer 2016). However, large pools of carbon sequestered in peatlands are vulnerable to changes in climate, primarily through altered fire regimes including larger, more severe fires that consume peat soils (Kasischke and Turetsky 2006; Grosse *et al.* 2011). Area burned in the North American boreal zone, which contains a high proportion of peatlands, is projected to increase up to 500% by the end of the 21st century due to climate change (Flannigan *et al.* 2009, Héon *et al.* 2014). Understanding the effects of current and future fire dynamics related to climate change requires knowledge of historical disturbance regimes (Bergeron *et al.* 2004*a*). Fire regime characteristics (e.g., frequency, extent, severity), for example, vary in conjunction with climate, topography, vegetative structure, and species composition, contributing to highly complex and regionally variable disturbance regimes (Wein *et al.* 1983; Zoltai *et al.* 1998).

Fire regimes differ widely within the global boreal zone despite similar physiography, climate, and "fire weather" conditions (e.g., humidity, temperature, winds; (Rogers *et al.* 2015). North American boreal fire regimes are characterized by infrequent (100 to 1000 year intervals), high-severity, stand-replacing fires (Wein *et al.* 1983; de Groot *et al.* 2013) which often eradicate legacies (e.g., wood) of past fires (Rolstad *et al.* 2017). By contrast, Eurasian boreal fire regimes are characterized primarily by relatively frequent (10–50 years) low-severity surface fires (Wooster 2004; de Groot *et al.* 2013; Drobyshev *et al.* 2014). Forest composition and the fire ecology of individual species contribute to the disparate fire regimes among high-latitude boreal forests across the globe (de Groot *et al.* 2013). Greater proportions of fire-dependent coniferous species (e.g., *Pinus spp.* and *Larix spp*.) are associated with frequent low-severity surface fires in lower boreal latitudes, whereas greater proportions of fire-resilient coniferous species (e.g., *Abies spp*. and *Picea spp*.) support less frequent high-severity crown fires in higher boreal latitudes (de Groot *et al*. 2013; Rogers *et al.* 2015). Fire-vegetation feedbacks greatly affect all boreal fire regimes, with overstory composition and fuel availability exerting a strong influence on fire severity in addition to fire weather (Walker *et al.* 2020).

Fine-scale variation and heterogeneity in forest composition is also characteristic of the North American hemiboreal subzone, the transition between boreal and temperate zones (Fig. 1; Brandt 2009). Much like Eurasian boreal forests, the hemiboreal subzone has high proportions of fire-dependent species (e.g., *Pinus resinosa*; (Heinselman 1973; Wein *et al.* 1983; Drobyshev *et al.* 2008). Fire regimes in hemiboreal forests may be fundamentally different from those of high-latitude boreal ecosystems in North America (Bergeron *et al.* 2004*a*; Brandt 2009). Despite vegetative similarities to Eurasian boreal systems, where fires have been reconstructed based on tree rings (Drobyshev *et al.* 2014) that allow detection of decadal return intervals and low-severity surface fires (Swetnam *et al.* 1999), North American hemiboreal peatland fire regimes have been characterized by long fire return intervals (100s–1,000s years) more typical of high-latitude North American boreal peatlands (Zoltai *et al.* 1998). Due to a paucity of data related to fire regimes in general and in peatlands especially, fire regimes across hemiboreal North America are often assumed to be similar to those of high-latitude boreal North America (Heinselman 1963, 1973; Bergeron *et al.* 2004*b*) regardless of vegetative characteristics.

Fire regimes in North American hemiboreal peatlands have generally been reconstructed via paleoecological analyses of sediments and charcoal (Booth and Jackson 2003; Booth *et al.* 2004) or settlement surveyor data (Whitney 1986; Cleland *et al.* 2004; Schulte and Mladenoff 2005). These methods are best suited for understanding high-severity fires that burn across large regions of continuous fuels as is typical for high-latitude North American boreal peatlands (Cyr *et al.* 2007, Kelly *et al.* 2013). Dendrochronology approaches can reconstruct frequent low-severity surface fires that are largely missed in sediment charcoal records and settlement surveyor data (Higuera *et al.* 2011; Remy *et al.* 2018). Given the higher proportion of fire-dependent species in hemiboreal peatlands, including *Pinus resinosa,* which is fire resistant and typically survives and records surface fires, there is an opportunity to reconstruct fire regimes in hemiboreal peatlands using fire-scarred trees to address the paucity of data generally and specifically for low-severity fires (Flannigan and Bergeron 1998; Drobyshev *et al.* 2008). Detecting and quantifying variability in fire regimes that include frequent low-severity fire and infrequent, high-severity fire is prerequisite to identifying ecological consequences of altered fire regimes (McLauchlan *et al.* 2020) and understanding impacts of altered fire dynamics in hemiboreal peatlands.

Our goal was to reconstruct historical fire regimes of hemiboreal peatlands in the Great Lakes Region prior to European settlement to evaluate (1) low- to moderate-severity fire frequencies for fire events; (2) synchrony of widespread fire events among forested uplands within and surrounding peatlands; and (3) climate-fire relationships.

Methods

Study area

The Great Lakes Region contains ca. 6 million ha of peatlands and represents the center of the hemiboreal subzone in North America (Fig. 1; Boelter and Verry 1977). Climate in the region is continental and modulated by the Great Lakes, with warm humid summers, cold winters, and annual precipitation dependent on proximity to the Great Lakes (Albert 1995). The most expansive peatlands in the Great Lakes Region occur in glacial outwash plains dominated by sandy soils, but smaller peatlands are intermixed with forested uplands at the margins of outwash plains, kettle depressions, end moraines, and stabilized dunes

(Heinselman 1963, 1965; Albert 1995). Near to the Great Lakes, forested dune fields typically protrude from peatlands (Silbernagel *et al.* 1997). Peatlands and uplands often intermix in the Great Lakes Region, resulting in high vegetative heterogeneity and species diversity (Silbernagel *et al.* 1997; Grondin *et al.* 2014).

We sampled forested uplands within and surrounding three hemiboreal peatlands in the Chequamegon-Nicolet and Hiawatha National Forests from northeastern Wisconsin to the eastern end of the upper peninsula of Michigan (Fig. 1) spanning ca. 320 km. The area sampled in each peatland ranged from 210 to 1200 ha (Table 1). We selected forested uplands within and surrounding peatlands and with minimal post-European settlement era land-use (1920s to present; Dickmann and Cleland 2005) where intact remnant wood with fire scars remained. Forested uplands surrounding peatlands were contiguous mixed-pine forests adjacent to the peatlands and generally extended into peatland margins. Forested uplands within peatlands included conifer-dominated islands (uplands with topographic relief and surrounded by peatland) and ridges (long, narrow uplands within peatlands; Fig. 2). At Haymeadow Flowage we sampled two adjacent uplands and six islands (Fig. 2a), at Ramsey Lake we sampled six ridges (Fig. 2b), and at Betchler Lake we sampled three adjacent uplands, one ridge, and 12 islands (Fig. 2c).

All sites were poor fens intermixed with dry to dry-mesic forested uplands. Poor fens are weakly minerotrophic, acidic peatlands with shallow peat (1–3 meters), continuous saturation of soils from a stable water table, and often transition sedge- and rush-dominated northern fens and sphagnum dominated bogs (Cohen *et al.* 2015). Fine-leaved sedges (*Carex spp.)* and low shrubs including leatherleaf (*Chamaedaphne calyculata)*, bog Labrador tea

(*Ledum groenlandicum*), bog birch (*Betula pumila*), and other *Ericaceae* were prevalent in the peatland vegetation of our sites (Minnesota Department of Natural Resources 2003). Sphagnum (*Sphagnum spp.*) was also abundant with variable development of hummock formation. Overstory trees of forested portions of peatlands included scattered tamarack (*Larix laricina*) and black spruce (*Picea mariana*). Forested uplands within and surrounding peatlands were predominantly red pine (*Pinus resinosa*) with occasional white pine (*P. strobus*), jack pine (*P. banksiana*), and *Populus spp.* Understories were sparse, dominated by bracken fern (*Pteridium aquilinum*) and wintergreen (*Gaultheria procumbens*).

Data collection and analysis

We collected fire-scarred samples (cross sections from remnant tree stumps or partial sections from living trees and snags) from multiple forested uplands within and surrounding peatlands to capture landscape-scale fires that burned across peatlands. We used targeted sampling in order to reconstruct fire history with relatively small sample sizes (Van Horne and Fulé 2006). Decomposition of remnant wood limited the availability of intact samples, especially on islands within peatlands where fire scars were evident but often unsampleable. We collected cross sections with chainsaws from remnant red pine – and occasionally white or jack pine – stumps, i.e., trees that were harvested during the Great Lakes Region cutover period (ca. 1850–1920). We selected only stumps that contained at least one fire scar and >50 growth rings. We nondestructively sampled select living trees, standing snags, and fallen snags with evidence of fire scars by removing partial sections (Arno and Sneck 1977).

We dried and surfaced all samples with increasingly finer-grit sand paper to reveal cellular structure of annual rings, and digitally scanned each sample to measure widths of annual rings (Speer 2010). In the laboratory, we used a dissecting microscope to crossdate tree samples using standard dendrochronological techniques, assigned exact calendar dates to all fire scars, and determined season of fire when possible (Grissino Mayer and Swetnam 2000; Speer 2010) based on fire-scar position. We followed the convention of assigning ring-boundary scars (dormant season position) to the subsequent year containing the earlywood immediately following fire scars (Muzika *et al.* 2015, Johnson and Kipfmueller 2016, Meunier *et al.* 2019b) and assessed the sensitivity of our major conclusions to this convention by repeating analyses with ring-boundary scars assigned to the previous year (Appendix A). We correlated ring width patterns to master chronologies for the region (Wendland and Swain Henselman 2002, Stambaugh and Guyette 2013, Stambaugh *et al.* 2013) using Cybis CDendro version 9.3.1 to assist with crossdating (Larsson 2018). We independently verified crossdating with two individual researchers. We compiled and analyzed fire scar data using Fire History Analysis and Exploration System (FHAES version 2.0.2) and the burnr package in R version 4.0.2 (Brewer *et al.* 2015; Malevich *et al.* 2018).

We analyzed fire frequency by estimating mean fire return intervals and filtering to identify synchronous, and more widespread, fire years. Level of filtering provides evidence of more widespread fires by selecting only fire events that are recorded by multiple samples at a study site (Farris *et al.* 2010, 2013; Meunier and Shea 2020). Spatially distributed fire-scarred tree samples record fires relative to area burned, with larger percentage of fire-scarred trees positively correlated with total area burned (Farris *et al.* 2010). We estimated mean fire return intervals at each site for fire years recorded on at least two samples for (1) all fire years with at least two samples recording; (2) fire years in which ≥ 10% of samples were scarred, (3) fire years in which ≥ 25% of samples were scarred; and (4) landscape fire years that were recorded on more than two forested uplands within and surrounding the peatlands. We assumed that synchronous fire events on multiple forested uplands (within and surrounding peatland sites) were indicative of widespread fires that burned across peatland landscapes. We omitted single-fire scar years to avoid including single-lightning scarred trees that may have been scarred but where fire did not spread. Using two or more fire-scarred samples avoided such events while still retaining small but ecologically significant fires.

We evaluated climate-fire relationships by superimposing fire years on a regional drought reconstruction and with superposed epoch analyses in the burnr package in R version 4.0.2 to compare regional interannual drought with the aggregated fire years from successive filtering (Grissino Mayer and Swetnam 2000; Cook *et al.* 2007). We averaged summer (June–August) Palmer Drought Severity Index (PDSI) for six PDSI grid points (206, 207, 215, 216, 224, 225) across Wisconsin and Michigan to reconstruct regional drought patterns during the period 1650–1950 when there was the most temporal overlap among tree-ring records (Cook *et al.* 2007, Falk *et al.* 2011). We analyzed climate-fire relationships for successive levels of filtering to identify more widespread fire events. We plotted fire years on averaged PDSI time series from 1650–1950 to evaluate climate-fire conditions (Palmer 1965). We also used superposed epoch analysis to compare climate conditions (averaged PDSI) in fire event years, and conditions prior to and following fire years, to randomly selected years from 1650–1950. We used 1000 non-parametric simulations for bootstrapped confidence intervals to assess statistical significance (*p-value* < 0.05) of departure from mean annual PDSI for fire years, as well as for two years prior to and after fire years (Grissino Mayer and Swetnam 2000; Malevich *et al.* 2018).

Results

We collected 220 fire-scarred tree samples in three hemiboreal peatlands across the upper Great Lakes Region from 2018–2019. We crossdated 129 samples (60% of all samples) spanning 1520 to 2019 and determined exact calendar year for 414 fire scars (128 unique fire years) ranging from 1548 to 1955 (Fig. 3). The number of samples we collected within sites directly correlated to the size of peatlands, with more sampling in larger sites (Table 1). Temporal extent of tree-ring records varied across the three sites with the shortest at Haymeadow Flowage (first year 1697) and the longest at Betchler Lake (first year 1520).

Prior to 1955 fires were historically frequent across peatland sites, with within-site mean fire return intervals from 7–31 years depending on site and level of filtering (Table 1). Mean fire return intervals increased with successive filtering levels as we selected for more widespread events. Filtering by synchronous fire years on forested uplands, which we expected to yield the longest mean fire intervals, produced results comparable to 10% and 25% filtering levels (7–27 vs. 10–31 years, Table 1).

Fire scars for which we could assign intra-annual ring position (53.7%) primarily occurred in the dormant and latewood positions (Table 2). Fire scars recorded at Haymeadow Flowage (n = 91) and Betchler Lake (n = 190) for which ring position was assigned were primarily within dormant ring positions, indicating these fire scars formed either after onset of dormancy (i.e., late fall) or prior to new wood formation (i.e., early spring) of the next year. Fire scars at Ramsey Lake (n = 132), for which ring position was assigned were predominantly in the latewood position (i.e., late growing season). Generally, fire seasonality was mixed, with fire events occurring in dormant, earlywood, and latewood positions. Sensitivity analyses (Appendix A) confirmed major conclusions were the same regardless of the year dormant fire scars (143 out of 413 total fire scars) were assigned to.

Fire years were synchronous among forested uplands within and surrounding all peatlands (Fig. 3 a-c), indicating fires likely burned across the peatland complexes. This pattern was independent of filtering method. Twenty percent of all fire years were synchronous among forested uplands within and surrounding peatlands and two of these synchronous fire years (1847 and 1891) occurred among multiple sites (Ramsey Lake and Haymeadow Flowage). We found five synchronous fire years in more than two sites (1787, 1825, 1847, 1891, and 1920) for fire years that scarred a minimum of two samples. At Haymeadow Flowage 48% of fire years were detected on only one sample (Fig. 3a), while 53% and 61% of fire years were detected on only one sample at Ramsey and Betchler Lakes respectively (Fig. 3b, Fig. 3c).

More than a quarter of fire years detected occurred during moderate regional drought and less than five percent of all fire events occurred during severe regional drought (Table 3; Palmer 1965). Widespread fire years with ≥ 25% of samples scarred and fires recorded across multiple peatlands occurred during regional mild and moderate droughts (Fig. 4; Palmer 1965). Only two fire years (1665 and 1910) occurred during regionally severe drought and no fire years occurred during extreme drought (Fig. 4; Palmer 1965). Fire years among all of the three peatland sites were associated with significantly (*p-value* < 0.05) dry conditions across all filters (Fig. 4). The year preceding fire years was also associated with significantly (*p-value* < 0.05) dry conditions except for the smallest fire years where at least two samples were scarred (Fig. 4).

Discussion

Peatlands in the hemiboreal zone differ from those in most of the North American boreal zone (Heinselman 1963, 1973; Schulte and Mladenoff 2005). Historical fire regimes in hemiboreal peatlands have largely been reconstructed using methods designed to capture infrequent high-severity fires (Whitney 1986; Cleland *et al.* 2004) that are typical for the North American boreal zone and burn thousands of hectares (Wein *et al.* 1983; Zoltai *et al.* 1998; Kasischke and Turetsky 2006). Our methods reconstructed fire regimes at finer spatial and temporal scales and we detected frequent low-severity fire events, which have been largely overlooked in North American peatland fire ecology (Cleland *et al.* 2004; Booth *et al.* 2004; Dickmann and Cleland 2005). Our results indicate that low-severity fire events were frequent (7–31 year mean fire return intervals; Table 1), widespread (Fig. 3), and an important component of hemiboreal peatland fire regimes. We sampled long-lived, fire-adapted and rot-resistant *Pinus resinosa* on forested uplands within and surrounding several peatland complexes to reconstruct low- to moderate-severity fire events using fine scale (annual to intra-annual resolution) dendrochronology. Moreover, we found that fire years did not occur during severe annual drought across the region but rather most often occurred during regional moderate drought conditions (Fig. 4).

Mean fire return intervals in our study sites (7–31 years; Table 1) were comparable to Eurasian boreal systems where more frequent and less severe fire is a key ecological process (de Groot *et al.* 2013; Drobyshev *et al.* 2014). Hemiboreal peatland fire regimes have been characterized by mean fire intervals of 100–200 years (Whitney 1986; Cleland *et al.* 2004), which is considerably longer than the intervals we found, and this difference is likely a result of different methodologies. Our results suggest that it is time to reassess the role of fire in hemiboreal peatlands and include both high- and low-severity fire when describing fire regimes of these systems. The exclusion of low-severity fire in hemiboreal peatlands since the mid-1900s (Fig. 3) could have unintended ecological consequences including losing fire-adapted species and changing fuels that carry fire which could contribute to reduced fire resistance of hemiboreal peatlands under a changing climate.

We analyzed synchrony of fire events within and among sites to estimate landscape (across uplands within and surrounding peatlands) and regional (among sites) scale fires and identify widespread fire years. Fires are spatially heterogeneous, and while fire scars cannot capture the spatial complexity or continuity of burning, fire-scar synchrony accurately represents area burned (Farris *et al.* 2010, 2013). Synchronous scarring results from widespread fires burning within and among sites (Farris *et al.* 2010) and is a useful way to understand fire events at multiple spatial scales (Morgan *et al.* 2001, Meunier and Shea 2020). Fire was synchronous and widespread (Fig. 3) within peatlands we studied including years like 1891 - a regionally significant fire year recorded by other studies across the region (Drobyshev *et al.* 2008; Muzika *et al.* 2015; Meunier and Shea 2020). We found a high level of synchrony of fire events among forested uplands within and surrounding peatlands, suggesting that fires were burning across different ecosystems within the larger landscapes. Similarly, we found relatively minor effects of different filtering levels (e.g., 10% or 25% scarred) also suggesting fires were widespread. However, we did not find a high degree of synchrony of fire years across the three different peatland complexes. This may be an artifact of our low sample depth, resulting in poor temporal overlap of chronologies among sites, and perhaps related to extensive distances among sites (Fig. 1), but it also highlights important variability in how climate, vegetation, and fire interact among different hemiboreal peatlands.

Determining seasonality is especially difficult in peatlands where successive summer droughts, which we detected in our SEA, could cause fires to burn continuously from fall into early spring (Scholten *et al.* 2021) corresponding to trees being scarred in either of two years or even in both years with latewood, dormant, and earlywood scar positions possibly resulting from the same fire event. Indeed, we observed a preponderance of back-to-back fire years at Betchler Lake including known large fire events (e.g., 1734/1735 and 1791/1792) which could be either fires burning across multiple seasons or multiple fire events, as fuel limitations are unlikely in this region compared to semi-arid regions. Similarly, there is little research in the Upper Great Lakes region on phenology of wood development hence no information on when latewood or earlywood formation begins and ends in red pine. However, our dating is consistent with other studies in this region including large fire years (Heinselman 1973, Drobyshev *et al.* 2008, Muzika *et al.* 2015, Guyette *et al.* 2016, Johnson and Kipfmueller 2016, Kipfmueller *et al.* 2017, Meunier *et al.* 2019a, Meunier *et al.* 2019b, Meunier and Shea 2020), and our major conclusions were the same regardless of whether dormant fire scars (143 of 413 total fire scars) were assigned to the previous or subsequent year (Appendix A).

Climatically driven fire regimes characterized by high-severity fire are typical of North American boreal ecosystems (Wein *et al.* 1983; Zoltai *et al.* 1998) and they are also an important part of North American hemiboreal landscapes (Heinselman 1965; Whitney 1986; Kasischke and Turetsky 2006)). While climate effects are often broad in scale, localized influences of plant species and ecosystem processes can also have strong influences on fire regime characteristics (Scheller and Mladenoff 2005; Loudermilk *et al.* 2013). Disparity among drivers of fire dynamics at fine scales in the North American boreal forest has relevant implications for hemiboreal peatlands (Sedano and Randerson 2014) where species composition, intermixing of uplands and peatlands, and greater landscape heterogeneity likely shape fire regimes.

Somewhat counterintuitively fire events in our study sites occurred during moderate drought conditions but not severe drought (Fig. 4). While somewhat surprising for peatlands, large fire years in the Great Lakes Region more generally have also occurred during moderate, but not severe, droughts (Guyette *et al.* 2016; Meunier and Shea 2020). Local and seasonal conditions, not just annual to multi-year regional drought conditions, may be a determinant of fire frequency and fire severity in hemiboreal peatlands. This finding suggests that fire-vegetation-climate interactions in hemiboreal peatlands, specifically in relation to frequent widespread low-severity fire events, are strongly influenced by short-term seasonal drying, forest composition, and fire ecology of species, but not by severe regional droughts.

Localized and seasonal drying disproportionately affect peatland surface vegetation, contributing to heterogeneity in peatland surface fuels even while belowground peat soils retain water (Shetler *et al.* 2008; Benscoter *et al.* 2015). Patterning in peatland surface fuels increases protection of peat soils by supporting rapid lateral fire movement through dried surface fuels while preventing vertical ground fire spread, limiting prolonged smoldering in peat soils, and preventing consumption of deeper peats (Shetler *et al.* 2008; Benscoter and Vitt 2008; Benscoter *et al.* 2015). These patterns are especially evident in transitional hemiboreal peatlands like poor fens where peat remains inundated with water throughout the year while finer surface fuels like sedges atop the peat dry out, promoting fire spread laterally across peatlands while vertical movement into peat soils is inhibited. These self-organizing patterns in peatland surface vegetation maintain peatland ecosystems' function and are reinforced by low- to moderate-severity fire (Benscoter *et al.* 2015). Frequent low-severity fires maintain diversity in peatlands by maintaining diverse fire-adapted plant communities, and long fire-free intervals in peatlands could result in decreased ecosystem stability and greater vulnerability to future disturbances (Benscoter *et al.* 2015; Flanagan *et al.* 2020).

While the role of fire varies widely among peatlands around the globe (Zoltai *et al.* 1998), frequent and widespread low-severity fire events play an integral part in the maintenance of peatlands including reducing encroachment by woody and non-peatland vegetation. This was particularly evident in the hemiboreal peatlands we studied with high abundances of fire-adapted plant communities (red and jack pine forests) and evidence of frequent and widespread low-severity fire events historically (fire-scarred trees on forested upland islands within expansive peatlands). Species composition (high proportion of fire-adapted species like *Pinus resinosa*), peatland surface fuel patterning, and localized drying likely maintained historical fire regimes in hemiboreal peatlands. Local variability in fire frequencies is also influenced by natural and anthropogenic ignition sources and barriers to fire spread (Falk *et al.* 2011). Altered fire regimes in peatlands, related to both increasingly severe fires driven by climate change and suppression of frequent and widespread low-severity fire, may destabilize peatland ecosystems making them more vulnerable to climate change and future disturbances (Flanagan *et al.* 2020). Peatlands in the Great Lakes Region are among the most vulnerable ecosystems under future climate change (Dahl 2011; Angel *et al.* 2018) and understanding the role of fire in relation to resilience in hemiboreal peatlands over the last 500 years is a necessary first step to determine how they will be affected by, and contribute to, a warming world.

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Table 1. Mean fire return intervals (MFRI) among hemiboreal peatlands of the upper Great Lakes Region.

Site	Area sampled(ha)	Crossdated samples	No. fire years	All fires MFRI(yr)	10% MFRI(yr)	25% MFRI(yr)	Landscape MFRI(yr)	Time span (yrs)
Haymeadow Flowage	210	26	25	8	10	18	7	1785–1944
Ramsey Lake	930	41	40	13	18	24	27	1637–1932
Betchler Lake	1220	62	77	10	15	31	21	1548–1955

Notes: Number of fire years corresponds to all years with fire events regardless of number of samples scarred. Mean fire return intervals (MFRI) were estimated only for fire events on at least two samples. Successive filtering (e.g., fire years occurred on ≥ 10% of fire-scarred samples and fire years occurred on ≥ 25% of fire-scarred samples) identifies more widespread fire events. Landscape mean fire return intervals were estimated for fire years recorded on more than two forested uplands within and surrounding peatlands. Time span corresponds to span between first and last fire year.

Table 2. Percentages of fire scars identified to dormant, earlywood, and latewood positions within tree rings and fire scars where ring position was not determined among hemiboreal peatlands of the upper Great Lakes Region.

Site	Unknown fire scars	Dormant fire scars	Earlywood fire scars	Latewood fire scars
Haymeadow Flowage	42.9%	50.5%	6.6%	0.0%
Ramsey Lake	46.2%	12.9%	3.8%	37.1%
Betchler Lake	47.9%	42.1%	0.5%	9.5%

Notes: Percentages were determined out of total number of fire scars at each site: Haymeadow Flowage (n = 91), Ramsey Lake (n = 132), and Betchler Lake (n = 190). Dormant corresponds to fire scars occurring between the latewood and earlywood ring margins and is assigned to the following earlywood year. Earlywood corresponds to fire scars occurring at any position (early, middle, or late) in the earlywood portion of the tree ring. Latewood corresponds to fire scars occurring at latewood positions in the tree ring.

Table 3. Percentages of fire years in corresponding drought conditions (Palmer 1965) among hemiboreal peatlands of the upper Great Lakes Region.

Drought condition	All fire years	10% scarred fire years	25% scarred fire years	Landscape fire years
Wetter, near normal, incipient drought	66.7%	66.7%	63.7%	64.0%
Mild and moderate drought	29.8%	28.2%	31.8%	36.0%
Severe drought	3.5%	5.1%	4.5%	0.0%

Notes: All fire years are years with fire events on at least two samples. Filtering (e.g., fire year occurred on ≥ 10% of fire-scarred samples and fire year occurred on ≥ 25% of fire-scarred samples) at the landscape scale identifies more widespread fire events. Landscape fire years are fire events recorded on > two forested uplands within and surrounding peatlands. Drought conditions are designations from Palmer 1965 with wetter, near normal, and incipient drought corresponding to PDSI ≥ -0.49, mild and moderate drought corresponding to -2.99 ≤ PDSI ≤ -0.50, and severe drought PDSI ≤ -3.00.

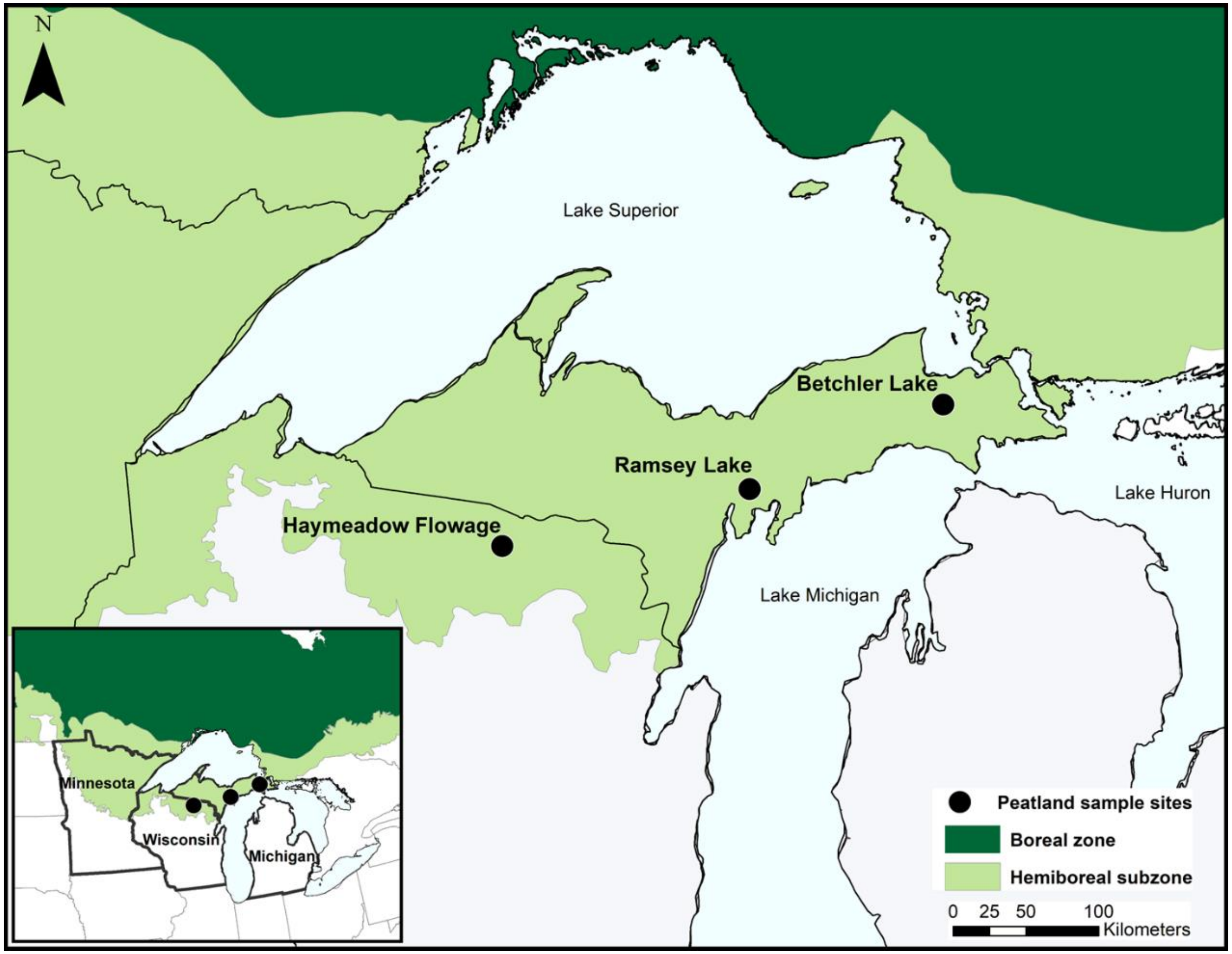

Fig. 1 (use color in print). Locations of peatland sample sites across the upper Great Lakes Region in North America with the true boreal and hemiboreal subzones (see Brandt 2009) differentiated. The inset shows the states of the upper Great Lakes Region: Minnesota, Wisconsin, and Michigan.

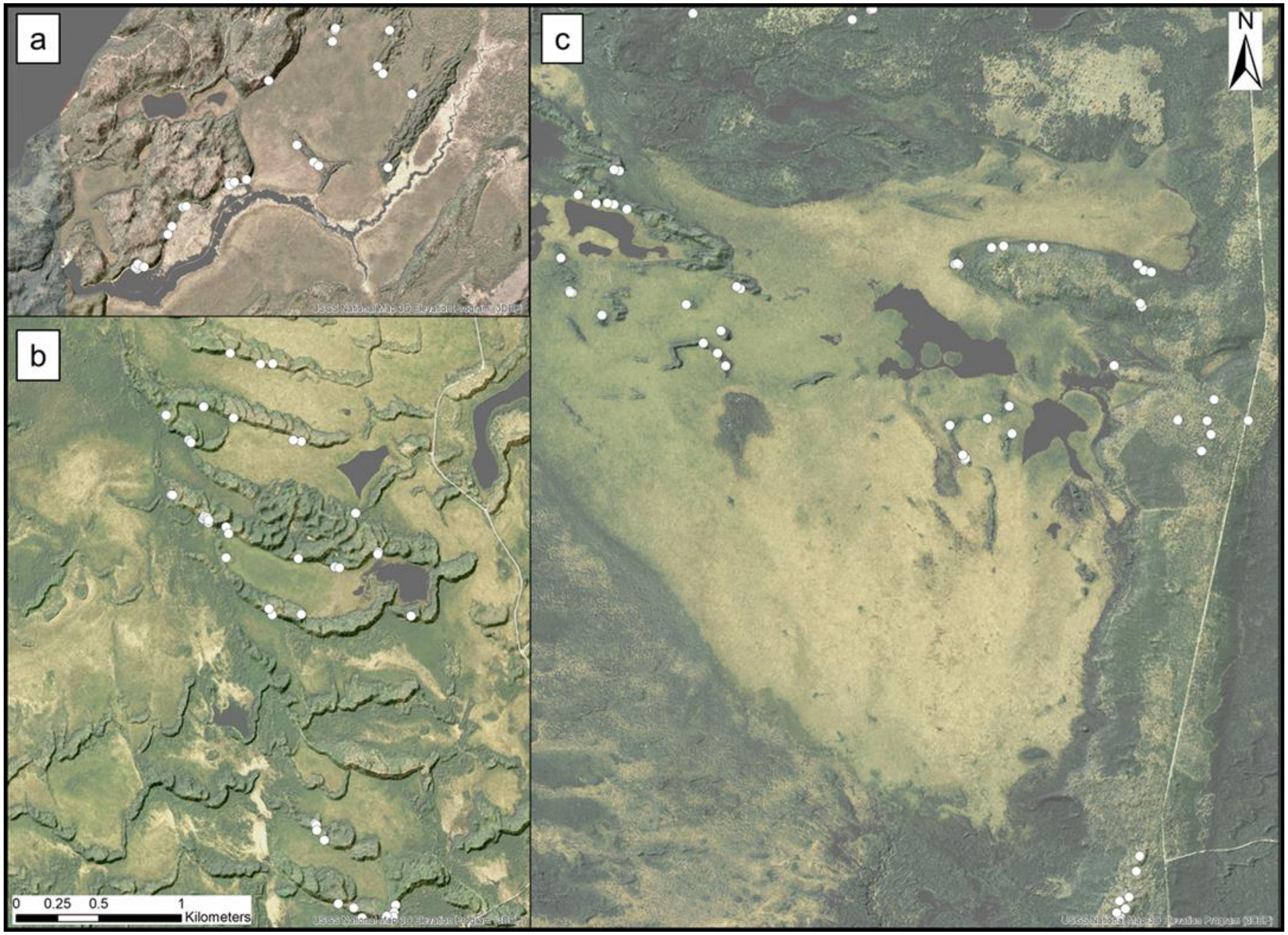

Fig. 2 (use color in print). Fire-scarred tree samples on forested uplands within and surrounding peatlands for (a) Haymeadow Flowage, (b) Ramsey Lake, and (c) Betchler Lake. Leaf-off aerial imagery has been overlaid with the USGS 3D Elevation Program Bare Earth Dynamic Elevation Model to distinguish vegetational and topographical differences used to delineate forested uplands within and surrounding peatlands.

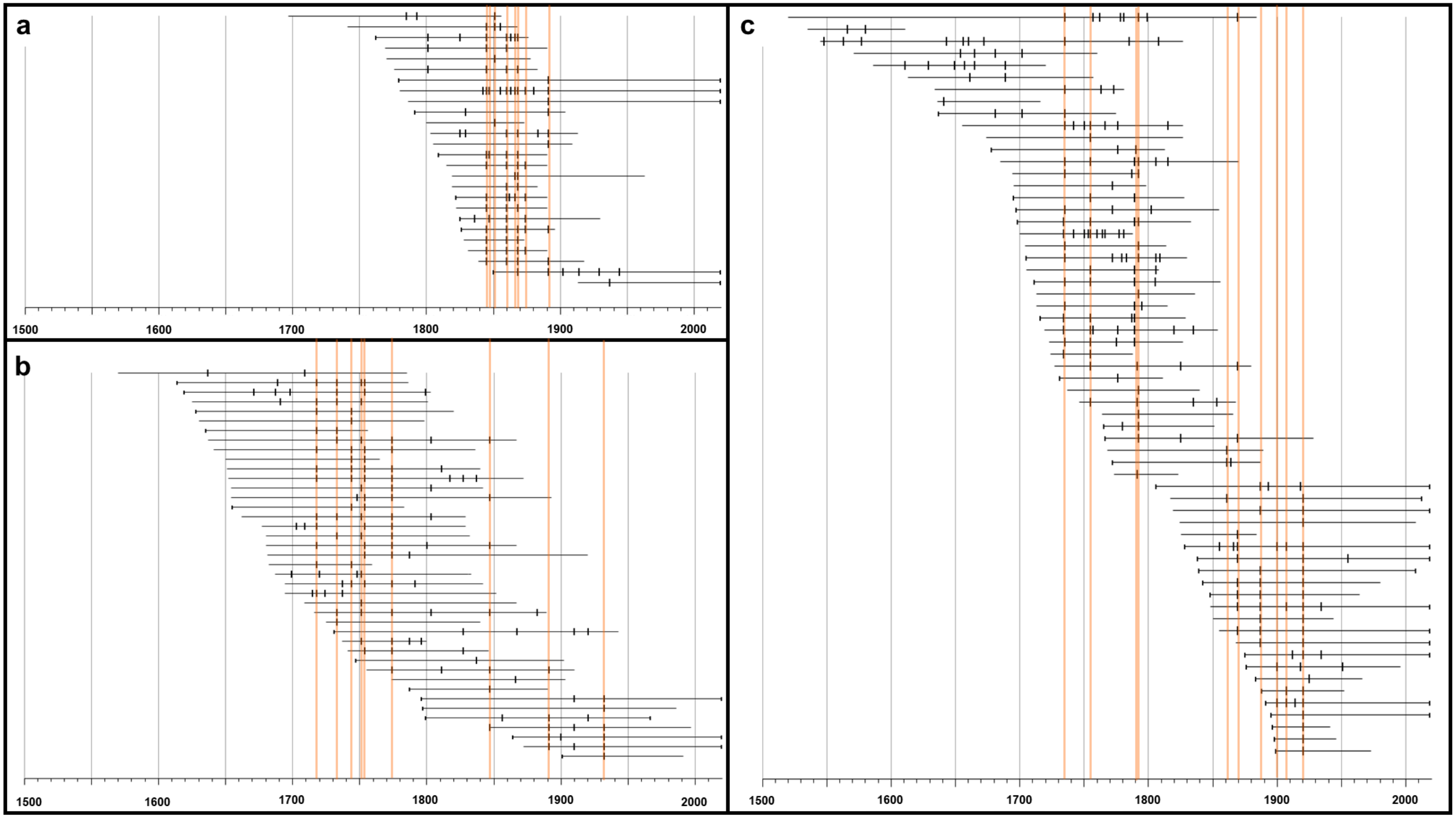

Fig. 3. Fire histories for three hemiboreal peatlands across the upper Great Lakes Region arranged by site. (a) Haymeadow Flowage, (b) Ramsey Lake, and (c) Betchler Lake. Each horizontal line is a sample (remnant stump, standing snag, fallen snag, or living tree), longer black vertical lines are recorded fire events, and shorter black lines are pith/bark years. Orange vertical lines highlight years where fire events were recorded on more than two forested uplands within and surrounding peatlands representing widespread fire years.

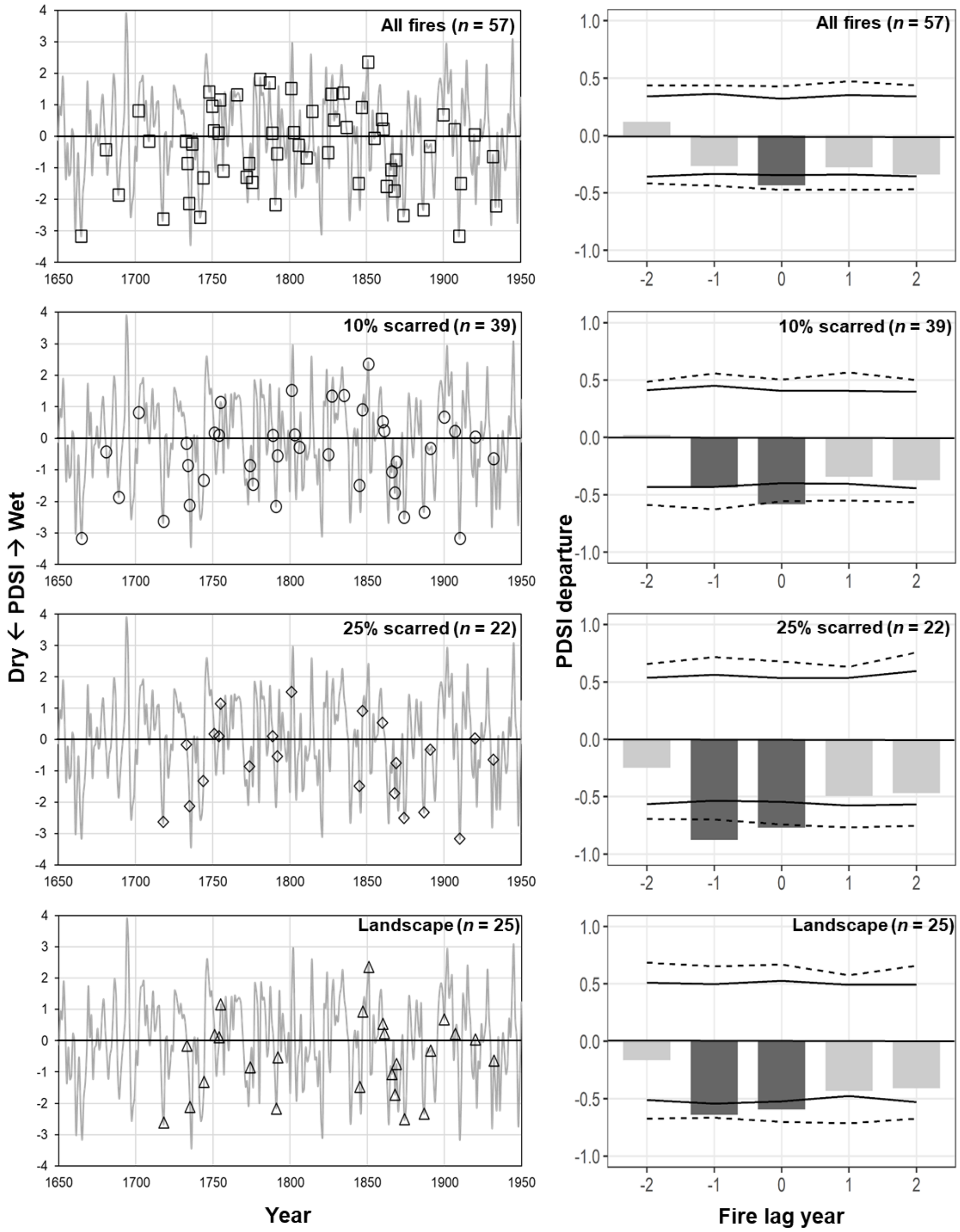

Fig. 4. Plotted average summer Palmer Drought Severity Index (PDSI; Cook *et al.* 2007) with fire years superimposed on the PDSI time series and superposed epoch analyses of departure from average PDSI across the upper Great Lakes Region during fire years. Fire years included years detected among the three hemiboreal peatland sites for all fire events recorded on at least two samples, fire events recorded ≥ 10% of samples, ≥ 25% samples, and fire events that occurred on more than two forested uplands within and surrounding peatlands at each site (Landscape). Positive PDSI indicate wet conditions and negative indicate dry conditions. Dark grey bars indicate a significant departure (*p-value* < 0.05) from average summer PDSI. Solid horizontal lines correspond to 95% confidence interval and dashed lines are 99% confidence interval.

Chapter 2. Widespread fire years across disparate ecoregions of the upper Great Lakes Region, USA

Abstract

Ecologically diverse regions like the upper Great Lakes Region in North America are useful for understanding impacts of climate and human land use changes particularly in relation to disturbance regimes. Disturbance regimes are scale dependent, dynamic processes and predicting the impacts of altered disturbance regimes on ecosystems requires historical context. Despite the importance of scale dependence in climate forcing of disturbance regimes, most fire history reconstructions across the upper Great Lakes Region have been site specific with limited regional scope. We used an extensive fire-scar network, spanning 240 kilometers and four disparate ecoregions, to evaluate variability in historical disturbance regimes across the upper Great Lakes Region. We estimated fire frequency, detected widespread fire years, and evaluated regional climate-fire relationships. We used synchronicity of fire events to detect widespread fire years by identifying peaks in percent fire-scarred tree samples, fire extent index (FEI), and synchronicity in fire events within and among study areas. Historically, fire events were frequent and widespread across the upper Great Lakes Region, and we identified 1689, 1752, 1754, 1791, and 1891 as regionally significant widespread fire years. Climate forcing at regional scales resulted in widespread fire years during regional drought (drought index $\leq$ -1.00) throughout the upper Great Lakes Region. During widespread fire years when fire events are synchronized by regional drought, fires are ubiquitous across disparate forest types and widespread fire years influence

ecosystems processes including responses to future disturbances. With an increasingly variable climate predicted across the upper Great Lakes Region, departures from historical disturbance regimes across the region could result in large-scale changes in ecosystem patterns and processes.

Introduction

Current and future changes in climate are projected to have marked impacts on the ecosystems of the upper Great Lakes Region especially among forested ecosystems (Kling *et al.* 2003; Pryor 2013). Forest productivity may initially increase with warming temperatures and longer growing seasons, but only persist while adequate moisture and nutrients are available (Boisvenue and Running 2006). Land surfaces are expected to become drier overall as warmer temperatures and increased evaporation rates will result in soil moisture deficits despite total increases in annual precipitation (Pryor 2013). Fire regime characteristics (e.g., frequency, severity, area burned) are the product of complex interactions of both climate and weather including short- and long-term droughts (Gill and Taylor 2009; Bigio *et al.* 2016). While fire activity is projected to increase in the upper Great Lakes Region with late-growing season droughts and decreases in soil moisture (Kling *et al.* 2003), there is only a burgeoning understanding of climate-fire relationships in the region (Drobyshev *et al.* 2012, 2015).

Climate-fire relationships across the upper Great Lakes Region are further complicated by rapid and widespread land-use changes that occurred during Euro-American settlement in the 19th century. From the mid-19th century into the early 20th century the upper Great Lakes Region was extensively logged, with approximately 20 million hectares deforested (Williams 1992). Current forests are more homogenous throughout the region with fire-adapted species like *Pinus resinosa* Ait. (red pine) declining (Frelich 1995; Schulte *et al.* 2007; Goring *et al.* 2016). Less structural complexity and lower species diversity reduces resistance and resilience further exacerbating impacts of climate change which are potentially compounded by novel disturbance regimes (Swanston *et al.* 2011).

The upper Great Lakes Region is characterized by diverse ecosystems in close spatial proximity, and this is a result of Great Lakes modulating local and regional climate across the region, physiographical heterogeneity created during postglacial erosion, and variability in soil formation relative to glacial deposit type (Albert 1995; Zhang *et al.* 2000). Fire frequent (prairies, drier mixed-pine forests, barrens, and savannas) and fire infrequent (wetlands, mesic hardwoods, *Pinus strobus* L. (white pine) and *Tsuga canadensis* (L.) Carrière (eastern hemlock) forests) ecosystems intermix in the upper Great Lakes Region, resulting in high vegetative heterogeneity and species diversity (Silbernagel *et al.* 1997, Grondin *et al.* 2014). While this intermixing of fire frequent and fire infrequent ecosystems can limit fire extent (Whitney 1986; Cleland *et al*. 2005), reconstructions of historical fire regimes in peatlands intermixed with mixed-pine uplands across the upper Great Lakes Region reveal that fire was frequent and widespread across seemingly disparate ecosystems (Sutheimer *et al.* 2021). The integration of fire histories across disparate forest types reveals interactions of local and regional scale patterns and processes that control fire regimes (Schulte and Mladenoff 2005; Falk *et al.* 2011; Swetnam *et al.* 2016) and the upper Great Lakes Region offers an unique opportunity to reconstruct fire regimes across disparate forest types that are in close spatial proximity.

Across the upper Great Lakes Region, site level fire histories are increasing in number and expanding in spatial coverage (Drobyshev *et al.* 2008*a*; Muzika *et al.* 2015; Guyette *et al.* 2016; Johnson and Kipfmueller 2016; Meunier *et al.* 2019b; Sutheimer *et al.* 2021) and support that, historically, fire was a fundamental process that shaped forested ecosystems. Specifically, low- to moderate-severity surface fires were frequent and ubiquitous across mixed-conifer forests throughout the region (Drobyshev *et al.* 2008a; Muzika *et al.* 2015; Guyette *et al.* 2016; Meunier and Shea 2020). Site level fire-scar reconstructions across the upper Great Lakes Region describe fire frequency, spatial extent of individual fires, fire seasonality, and fire severity (Kipfmueller *et al.* 2017, Meunier *et al.*, 2019a; Drobyshev 2008b; Stambaugh *et al.* 2021), but with historical and projected changes in the region there is a need to understand fire in a regional context. This context will require networks of sites that span various forest types, physiography, and climate. Specifically, fire-scar networks across regions can identify widespread and synchronous fire events among disparate forest types that correspond to regional scale drivers of fire regimes (Swetnam and Betancourt 1990; Swetnam *et al.* 1999; Brown *et al.* 2001).

This study takes advantage of unique landscapes and site-level fire histories across the upper Great Lakes Region to create a more expansive fire-scar network allowing us to better understand regional drivers of fire regimes. Our goal was to use an extensive fire-scar network across disparate forest types of the upper Great Lake Region to (1) evaluate similarities and differences of fire frequencies among forest types; (2) detect widespread fire years and regionally significant fire years among study areas; and (3) to evaluate if fires were synchronized by climate across the region or primarily asynchronous and driven by local factors.

Methods

Study area

The Upper Peninsula of Michigan (UP) occupies more than four million hectares of the upper Great Lakes Region of North America, USA (Fig. 5). The UP is strongly influenced by three of the five Great Lakes and contains 13 ecoregions differentiated by climate, physiography, and vegetation (Fig. 5; Table 4). Glaciation in the UP ended around 9500 years with postglacial erosion and soil formation on glacial deposits contributing to modern physiography (Peterson 1986; Albert 1995). Climate across the UP is continental with increased lake-effect precipitation and moderation of temperature extremes nearest the Great Lakes (Table 4). Northern hardwood forests are abundant in the west and were predominant in Huron Mountains and Sturgeon River Gorge study areas (Table 4; Fig. 6 *a,b*). Dry mixed-pine forests are abundant in the east and were predominant in the Hiawatha National Forest East and Hiawatha National Forest West study areas (Table 4; Fig. 6 *c,d*). Throughout the central and eastern portions of the UP peatlands are extensive in the poorly drained lacustrine deposits with sandy well-drained ridges, islands, and dunes supporting mixed-pine forests rising from the peatlands (Table 4; Fig. 6 *e,f*). Seney National Wildlife Refuge, Hiawatha National Forest West, and Hiawatha National Forest East all contained peatland complexes intermixed with mixed-pine forests.

Data collection and analyses

Targeted sampling was used to reconstruct fire history for all five of the study areas (Van Horne and Fulé 2006). We used previously published fire histories from the Huron Mountains (Muzika *et al.* 2015) and Seney National Wildlife Refuge (Drobyshev *et al.* 2008*a*, 2008*b*, 2012) in this study in addition to collecting fire history in the Sturgeon River Gorge, Hiawatha National Forest East, and Hiawatha National Forest West (Fig 5). We collected cross sections with chainsaws from remnant *Pinus resinosa* Ait. (red pine) stumps (i.e., trees that were harvested during the upper Great Lakes Region cutover period ca. 1850–1920) and occasionally *Pinus strobus* L. (white pine) or *Pinus banksiana* Lamb. (jack pine) stumps. We selected only stumps that contained at least one fire scar and >50 growth rings. We nondestructively sampled select living trees and snags with evidence of fire scars by removing partial sections (Arno and Sneck 1977).

We dried the samples, surfaced samples with increasingly finer-grit sand paper to reveal cellular structure of annual rings, and digitally scanned each sample to measure annual ring widths (Speer 2010). In the laboratory, we used a microscope and crossdated samples using standard dendrochronological techniques, assigned exact calendar dates to all fire scars, and determined season when possible (Grissino-Mayer and Swetnam 2000; Speer 2010). We correlated ring width patterns to master chronologies for the region (Wendland and Swain Henselman 2002; Stambaugh and Guyette 2013; Stambaugh *et al.* 2013) using Cybis CDendro version 9.3.1 to assist with crossdating (Larsson 2018). We independently verified crossdating with two individual researchers. We compiled data using Fire History Analysis and Exploration System (FHAES version 2.0.2) and conducted all subsequent analyses on composite study area chronologies.

We analyzed fire scar data using the burnr package in R version 4.0.2 (Brewer et al. 2015; Malevich et al. 2018). We used filters based on percentage of fire-scarred samples to identify fire years of various spatial extents within each study area (Swetnam and Baisan 2003). We used percentage-scarred filters to identify fire events of increasing extent within each study area (Swetnam and Baisan 2003). Spatially distributed fire-scarred samples record fires relative to the area burned and synchrony among samples within a study area identifies more extensive fires that burned large portions of the study area (Falk *et al.* 2007; Farris *et al.* 2010, 2013). We filtered fire events to include fires that scarred at least two samples within a study area to capture ecologically meaningful but smaller fires (e.g., beyond a single lightning-struck tree), moderately sized fires that scarred ≥ 10% of samples within a study area, and large fires that scarred ≥ 25% of samples within a study area. We composited fire events for each filtering method within each study area to estimate mean fire return intervals (Falk *et al.* 2007). We assessed variability and distribution of fire return intervals for each filtered set of fire events at each study area.

We identified widespread fire years across the region by (a) identifying peaks in percent fire-scarred tree samples, (b) fire extent index (FEI), and (c) synchrony of fire events within and among study areas. We restricted this analysis to fire events that occurred after 1650, when all study areas were recording fires. We compiled all fire-scarred samples across the region and identified the years where the most samples were scarred. FEI estimates relative spatial extent and fire severity of individual years; larger FEI values correspond to more widespread fire years (Guyette *et al.* 2016). We defined $FEI(x)$ as the product of the number of study areas recording fire in year $x(n)$ and the percentage of all fire-scarred trees in year $x(s)$.

$$FEI(x) = ns$$

We also identified widespread fire years as years with synchrony of fire events within and among study areas across the region identifying fire events that scarred ≥ 25% of all fire-scarred tree samples within a study area and were synchronous among at least two study areas. Regionally significant fire years were the most widespread fire years that had the largest FEI values and were synchronous within (≥ 25% fire-scarred samples) and among study areas (at least two study areas). We did not include percent fire-scarred samples to identify regionally significant fire years because it is already incorporated through FEI.

Synchrony among fire events is widely applied to multiscale and regional fire analyses to detect years when historical fires burned thousands of hectares (Drobyshev *et al.* 2015; Swetnam *et al.* 2016; Meunier and Shea 2020). While fire-scars cannot capture the spatial complexity or continuity of burning of individual fires, fire-scar synchrony among spatially distributed study areas that record a fire in a given year provides a relative index of total area burned (Morrison and Swanson 1990; Swetnam 1993; Taylor and Skinner 1998). Furthermore, evidence shows that synchronous low-severity, surface fires among many landscapes correspond well to widespread fire years where fires were burning extensively at the regional scale (Drobyshev *et al.* 2014, 2015; Swetnam *et al.* 2016). We did not weight detected fire events by study area size or number of samples in a study area due to the temporal and spatial variability of fire histories and local-scale drivers of fire regimes in individual study areas. Support for not including weighting protocols includes difficulty in discriminating study area properties across geographically wide and temporally long fire chronologies, limiting the influence of larger landscapes with more samples on the overall regional analyses, and preserving the most data across the most expansive geographic and longest temporal ranges (Drobyshev *et al.* 2014).

We used growing season (June–August) Palmer Modified Drought Index (PMDI) to assess relationships between historical climate and widespread fire years. PMDI integrates drought reconstructions from tree ring networks, independent from fire-scar networks, and instrumental data and is a recent Palmer Drought Index recalibration that improved spatial and temporal coverage of drought at a higher spatial resolution throughout North America (Cook *et al.* 2010). Palmer Drought indices are influenced by precipitation, air temperature. and soil moisture with negative values corresponding to dry periods and positive values corresponding to wet periods (Palmer 1965). We obtained PMDI values from the Living Blended Drought Atlas (Cook *et al.* 2010) and averaged growing season PMDI values from 17 grid points within the UP to reconstruct annual growing season drought for the analysis period, 1650–2000.

We superimposed widespread fire years from our fire-scar network on a moving average of all PMDI values across the 17 gridpoints to compare the occurrence of these fire years to broad-scale patterns in average PMDI across the region over time. We evaluated climate-fire relationships using superposed epoch analysis (SEA; Swetnam and Baisan 2003; Swetnam and Betancourt 1990; Grissino-Mayer and Swetnam 2000) in the R burnr package version 4.0.2 (Malevich *et al.* 2018) to compare average PMDI during, before, and after fire event years. Widespread fire years were defined by largest percent trees scarred, largest FEI, and greatest synchrony of fire events among the five study areas across the UP. We used 1000 non-parametric simulations for bootstrapped confidence intervals to assess statistical significance (p-value < 0.05) of departure from mean annual PMDI for widespread fire years, as well as for two years prior to and after fire years (Grissino Mayer and Swetnam 2000, Malevich et al. 2018).

Results

Fire frequency

From 1650 –1950, the period with the most overlap in fire histories across the five study areas, fire was frequent but also variable across the UP (Figs. 7, 8). Composited fire events that scarred more samples within study areas generally had longer mean fire return intervals except in the Sturgeon River Gorge where mean fire return interval was the same for fire events that scarred ≥ 2 samples and for fire events that scarred ≥ 10% samples (Table 5). Across the five study areas sampled in the UP, mean fire return intervals for fire years recorded on ≥ 2 samples ranged from 3–17 years, ≥ 10% fire-scarred samples ranged from 9–21 years, and on ≥ 25% fire-scarred samples ranged from 17–45 years (Table 5). Seney National Wildlife Refuge had both the shortest mean fire return interval when including smaller fires (all fires) and the longest mean fire return interval for larger fires (25% filter, Table 5).

In central UP study areas (Hiawatha NF West and Seney National Wildlife Refuge), the period of 1800–1847 corresponded to many smaller fires and an absence of larger fires (≥ 25% fire-scarred samples) which was dissimilar to the western UP study areas (Sturgeon River Gorge Wilderness and Huron Mountains, Fig. 7). Fires across the entire region decreased after 1900 and after 1950 fires only occurred in Seney National Wildlife Refuge (e.g., 1976, Fig. 7). Smaller fires (recorded on ≥ 2 fire-scarred samples) and fires that scarred ≥ 10% samples were more frequent and less variable in central and eastern UP (Seney National Wildlife Refuge and Hiawatha National Forest zones) as compared to the western UP study areas (Sturgeon River Gorge and Huron Mountains; Fig. 4). The greatest variability in fire return intervals for all study areas occurred for larger fires that scarred ≥ 25% samples, with the longest overall fire return interval (93 years) recorded in the Hiawatha National Forest West zone (Fig. 8). Minimum fire return interval among all study areas was 1 year.

Widespread fire years

We detected 16 unique widespread fire years across the UP from 1650–2000 using total percent-scarred samples, fire extent index, and synchrony within and among study areas. Each widespread fire year detected by percent-scarring (*n*=14) scarred more than 10% of all samples (Fig. 9*a*). Widespread fire years with the largest values of fire extent index (*n*=11) each had a fire extent index greater than 20 (Fig. 9*b*). 1689, 1752, 1754, 1791, 1884, and 1891 were widespread fire years that were synchronous within (≥ 25% fire-scarred samples) and among study areas (at least two study areas; Fig. 7*d*). Widespread fire years were most frequent during 1750–1800 (*n* = 4) and least frequent during 1800–1850 (*n* = 1), 1900–1950 (*n* = 1), and 1950–2000 (*n* = 1). Mean fire return interval for widespread fire years (*n*=16) was 21 years.

We identified 1689, 1752, 1754, 1791, and 1891 as the most widespread and regionally significant fire years that had the largest FEI values and the most synchrony within and among study areas (Fig. 7*d*; Fig. 9*a*; Fig 10). 1791 and 1891 were the most extensive fires across the region and similarly scarred high percentages of samples within study areas (Fig. 7, Fig. 10). Fires during 1689 were extensive across the region but scarred lower percentages of samples as compared to 1791 and 1891 (Fig. 10). 1752 was extensive and fires in western UP scarred high percentages of samples (57% of Sturgeon River Gorge samples and 39% of Huron Mountains samples; Fig. 6). 1754 was the least spatially extensive fire year and fires in central UP scarred high percentages of samples (50% of Hiawatha National Forest West samples and 34% of Seney National Wildlife Refuge samples; Fig. 10).

Climate-fire relationships

We used superposed epoch analysis to detect significant departures in average Palmer Modified Drought Index (PMDI; Cook *et al.* 2010) before, during and after widespread fire years (n=16) to investigate climate-fire relationships. Widespread fire years corresponded to significant negative departures in average PMDI ($p < 0.05$) corresponding to regional drought conditions during the late growing season (June–August; Fig. 11*a*). No other significant departures in average PMDI occurred before or after widespread fire years suggesting that regional seasonal drought within a single year was important for widespread fire years and multi-year drought conditions did not occur before or after regionally widespread fire years (Fig. 11*a*). All but three of widespread fire years across the region occurred during drought conditions (Fig. 11*b*; Palmer 1965). Eight of the most widespread fire years occurred in years with moderate and severe regional drought conditions ($-2 \geq$ PMDI > -4) and one year, 1910, occurred during extreme regional drought conditions (PMDI < -4; Fig. 11*b*; Palmer 1965).

Discussion

We developed the first broad scale fire-scar network across the UP, a region characterized by highly variable ecosystems and climate all in proximity, allowing us a unique opportunity to examine drivers of fire regimes regionally. Our study areas spanned four different ecoregions including dry, outwash sand plains, large peatland complexes, highly dissected glacial moraines, and sandy ridges along Lake Superior (Fig. 6). We found that in all these study areas (covering 68 forested sites) fires were historically frequent (3–45 year mean fire return intervals; Table 5), fire regimes were similar (e.g., Fig. 7), and fires were often widespread and drought driven (Fig. 9). Fire regimes were variable with some landscapes characterized primarily by smaller less extensive but frequent fires (e.g., Seney NWR), and others where larger fires were relatively common (e.g., Hiawatha NF East, Fig. 8). Interestingly, in spite of one of the most intense periods of logging and other land use changes in the mid-to late-19th century, fire frequencies during and after this time were similar to prior centuries. It was not until the early 20th century when effective fire exclusion began did we find anomalous fire regimes where fire events among all study areas were nearly absent.

Fire frequency

The three new study areas we sampled further expanded the coverage of this regional fire-scar network and corroborated findings from previous studies further elucidating that fires throughout the region were frequent, especially smaller fires. Within central and eastern study areas where mixed-pine forests were dominant in the surrounding landscapes mean fire return intervals were shorter (3–7 years) and less variable compared to western study areas

(14–17 years) where northern hardwood forests were dominant in the surrounding landscapes. Variability in fire frequencies at finer scales (<10000 ha) is driven by temporal and spatial variations in vegetation, natural and anthropogenic ignition sources, physiography, weather, and barriers to fire spread (Falk *et al.* 2011). In addition, the number of smaller fires detected increases significantly with increasing sample size while number of widespread fires detected varies less with sample size (Farris *et al.* 2013). Variability in temporal and spatial characteristics among study areas influenced small fires; however, the longer mean fire return intervals we observed for small fires in the western study areas are most likely a result of fewer total samples (n = 101) compared to the rest of the region (n = 446). This is strongly supported as Seney National Wildlife Refuge had the shortest mean fire return interval for small fires and had a sample size two to ten times larger than all other study areas. Fire return intervals for larger fires were variable within study areas but not as variable among study areas (Fig. 7).

After 1900, frequency of fires among all study areas declined significantly, and after 1950 no fires were detected other than in Seney National Wildlife Refuge (Fig. 7). In Seney National Wildlife Refuge, a large wildfire in 1976 burned 260 km^2 from July to September during windy and dry conditions (Anderson 1982). 1976 was a major fire year in Seney National Wildlife Refuge (Drobyshev *et al.* 2008*a*) and while we detected it in our fire histories it was not a regionally widespread fire year. Fire suppression in the region began in the 1920s and contributed to decreases in fire frequency and extent throughout the upper Great Lakes Region (Dickmann and Cleland 2005). We observed longer fire return intervals and decreases in fire frequency throughout all our study areas after 1920 (Fig. 7). The one exception is Seney National Wildlife Refuge where prescribed fire has been used since 1935 and management plans include allowing wildfires to burn if naturally ignited with low threat potential (Marsh 2013; Corace and Shartell 2013).

Widespread fire years

Fire-scar networks that reconstruct regional patterns of fire activity are necessary to understand broad-scale drivers in dynamic and diverse landscapes (Vale 2002; Swetnam *et al.* 2016; Dewar *et al.* 2020). Our study is one of the first to compile synchronous fire events throughout the UP, an area of more than four million hectares. We identified regionally significant fire years in the UP including the five most widespread fire years: 1689, 1752, 1754, 1791, and 1891. These fire years in addition to other widespread fire years we detected, 1664, 1665, 1864, 1780, and 1910, have been identified elsewhere as regionally significant fire years in the upper Great Lakes Region and North America (Heinselman 1973; McMurry *et al.* 2007; Guyette *et al.* 2016; Meunier and Shea 2020).

Both 1752 and 1754 were regionally significant fire years that corresponded to fires that scarred high percentages of samples. However, fires in 1752 were most extensive in the eastern portion of the UP while fires in 1754 were most extensive in the central portion of the UP indicating important differences in local controls of fire regimes. Regional fire-scar networks provide the most comprehensive reconstruction of fire regimes by using synchrony to identify major fire years that are climatically driven and by highlighting variability in synchrony that results from local drivers at finer scales (Falk *et al.* 2011). If we had conducted our analyses in only the eastern portion of the UP or only the central portion of the UP, we would not have identified both 1752 and 1754 as regionally significant fire years and would not have identified the interaction of climate and local controls in regulating fire regimes in these areas.

Climate-fire relationships

Fire-scar networks are essential to understand interactions between local- and broad-scale drivers of fire regimes (Falk *et al.* 2011; Swetnam *et al.* 2016). Synchronous, more widespread fire patterns are indicative of broad-scale regional drivers, like climate, governing fire occurrence and variability in widespread fire patterns suggests influences of local drivers (Heyerdahl *et al.* 2001). Our data illustrates the importance of regional growing-season (June – August) drought in the upper Great Lakes Region in synchronizing fire events resulting in widespread fire years (Fig. 11). However, variability in fire frequencies among study areas (Fig. 8) at the local scale and differences in extent of widespread fire years at the regional scale (Fig. 10) indicate regional and local scale drivers acted simultaneously to influence historical fire regimes. This underscores the importance of interactions between regional drivers (climate, extensive human land use change) and local drivers (ignition sources, vegetation, physiography, local weather, barriers to fire spread) in regulating fire regimes in the upper Great Lakes Region.

Historically, climate synchronized fire activity at regional scales, resulting in widespread fire years throughout North America and Europe (Lafon 2010; Falk *et al.* 2011; Drobyshev *et al.* 2017)**.** Extensive climate-driven fires spread widely, disproportionately burning large areas in the absence of human fire suppression and artificial fuel breaks (Schulte and Mladenoff 2005; Lafon 2010; Drobyshev *et al.* 2015). Mixed-pine forests with fire-adapted red pine were historically maintained by frequent surface fires across the upper

Great Lakes Region, and fire exclusion since the early 20th century has contributed to loss of mixed-pine forests throughout the region (Bergeron and Brisson 1990; Frelich 1995; Flannigan and Bergeron 1998). Climate variability and late summer heat are projected to increase throughout the upper Great Lakes Region with expectations of increased frequency of extreme late growing season droughts despite annual precipitation increasing overall (Warner 2021). Forest health and productivity may decline as changes in frequency, size, and severity of fire events alter fire regimes across the upper Great Lakes Region (Millar and Stephenson 2015; Clark *et al.* 2016). With an increasingly variable climate predicted across the upper Great Lakes Region and altered disturbance regimes, large-scale changes in ecosystem patterns and processes are likely to continue.

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Table 4. Characteristics[a] of ecoregions sampled across Upper Peninsula of Michigan.

Ecoregion	Study areas	Forest types	Physiography	Climate
Keweenaw-Baraga Moraines	Sturgeon River Gorge	Northern hardwood forest {*Acer saccharum* Marshall (sugar maple), *Acer rubrum* L. (red maple), *Betula alleghaniensis* Britton (yellow birch), *Populus grandidentata* Michx. (bigtooth aspen), *Populus tremuloides* Michx. (quaking aspen)}; *Pinus resinosa* Ait. (red pine), *Pinus strobus* L. (white pine), *Tsuga canadensis* (L.) Carrière (eastern hemlock)) abundant historically on ridges but declining	Broad ridges with well-drained sandy soils 150 to 500 feet high; gullies on steep slopes of moraines; poorly drained sandy lake plain near Lake Superior but not extensive	Growing season: Relatively cool, 110 to 130 days near Lake Superior Precipitation: Average rainfall 76 to 81 cm; average snowfall 356 cm to 508 cm
Michigamme Highlands	Huron Mountains	Northern hardwood forest with *Quercus rubra* L. (red oak), red pine, and white pine occurring on excessively drained soils and exposed bedrock, localized *Pinus banksiana* Lamb. (jack pine) barrens	Steep sandy till deposits and large outwash plains; Exposed ridges of granite or sandstone bedrock 500 to 800 feet high occur in Huron Mountains	Growing season: 75 to 150 days, longest along Lake Superior Precipitation: Average rainfall 81 cm to 91 cm; average snowfall 330 cm along Lake Superior to 508 cm inland

Ecoregion	Study area	Vegetation	Physiography	Climate
Grand Marais Lakeshore	Hiawatha National Forest East Hiawatha National Forest West (6 sites)	Red pine and jack pine ridges and dunes along Lake Superior; Interior uplands with red pine and jack pine with scattered northern hardwoods and eastern hemlock-white pine forests; Peatlands with *Picea mariana* (Mill.) Britton, Sterns & Poggenb. (black spruce), Thuja occidentalis L. (arborvitae), Larix laricina (Du Roi) K. Koch (tamarack) and sandy ridges with white and red pine within peatlands	Well-drained sandy ridges and dunes along Lake Superior; Extensive peatlands in poorly drained lacustrine deposits; bogs with deep peat in western kettles	Growing season: 100 days inland to 140 days along Lake Superior Precipitation: Average rainfall 81 cm to 86 cm; average snowfall 254 cm to 457 cm along Lake Superior
Seney-Tahquamenon Sand Plain	Seney National Wildlife Refuge Hiawatha National Forest West (3 sites)	Mixed conifer swamp, muskeg/bog, and patterned peatlands dominated by tamarack and black spruce on poorly drained sand lake plain; Mixed pine forests (red pine, jack pine, and white pine) on sandy ridges and dunes	Poorly drained sand lake plain with large expanses of wetlands; Well drained glacial outwash and lacustrine deposits support transverse dune complexes	Growing season: <100 days in central frost pocket of the ecoregion to 230 days along edges Precipitation: Average rainfall 81 cm to 86 cm; average snowfall 203 cm to 305 cm nearest Lake Superior

[a] Characteristics modified from Albert 1995.

Table 5. Fire history data summarized by study area across Upper Peninsula of Michigan
Fire history information from year of first fire event to year each study area was sampled, organized by longitude (west to east).

Study area	No. sites	No. Samples	No. fire scars	No. years w/ fire	MFRI All[a]	MFRI 10%[b]	MFRI 25%[c]	Years
Sturgeon River Gorge	2	24	82	30	17	17	27	1659–2020
Huron Mountains [D]	5	77	261	46	14	18	23	1510–2005
Hiawatha NF West	9	114	433	156	5	10	29	1574–2019
Seney NWR [E]	50	255	919	203	3	21	45	1596–2006
Hiawatha NF East	2	77	257	93	7	9	17	1548–2018

[a] MFRI All is mean fire return interval (years) for fire events on ≥ 2 samples
[b] MFRI 10% is mean fire return interval (years) for fire events on ≥ 2 samples and 10% of samples
[c] MFRI 25% is mean fire return interval (years) for fire events on ≥ 2 samples and 25% of samples
[d] Data provided by Dr. Michael C. Stambaugh (Muzika *et al.* 2015)
[e] Data provided by Dr. Igor Drobyshev (Drobyshev *et al.* 2008*a*, 2008*b*, 2012

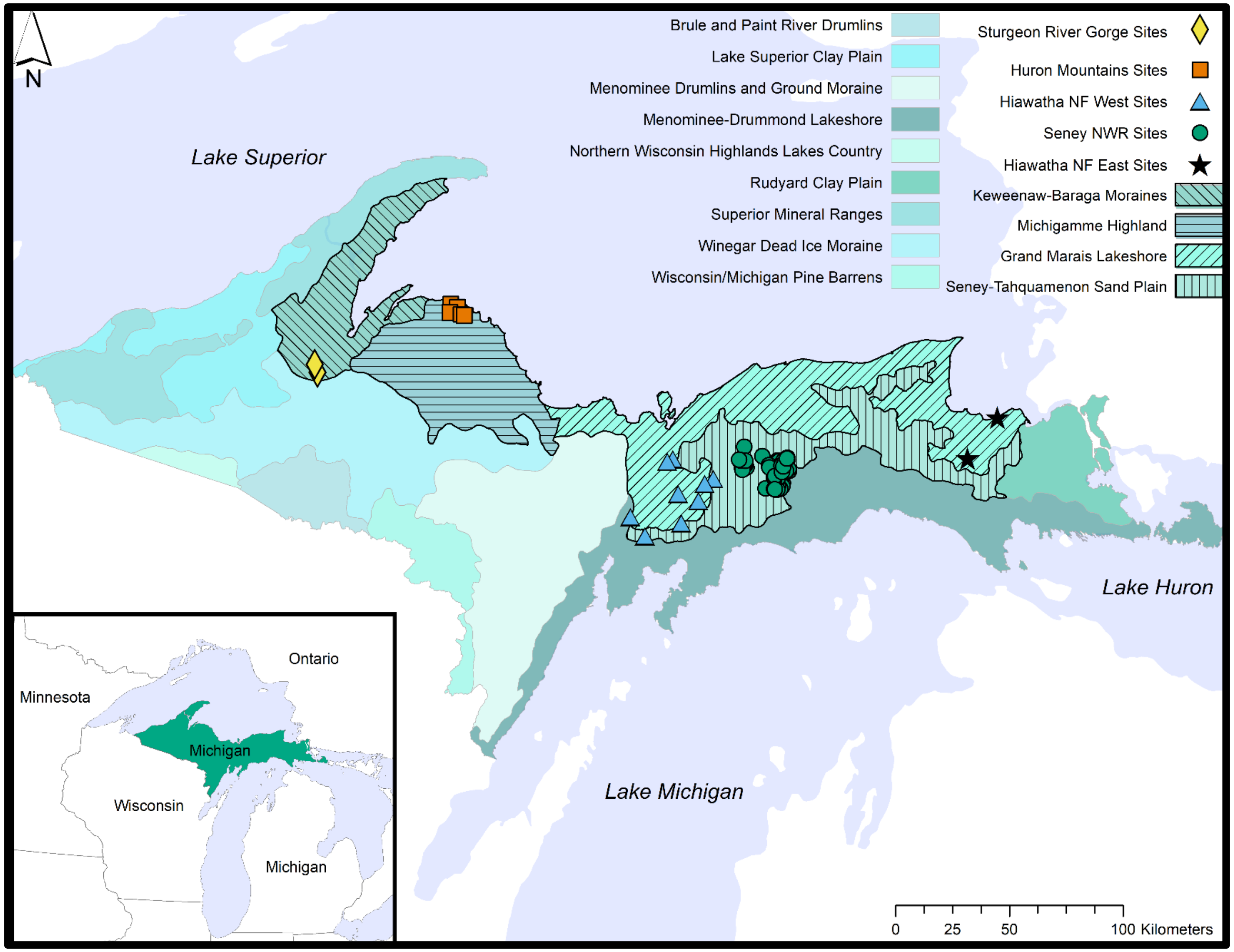

Fig. 5. Location of study areas spanning multiple ecoregions of the Upper Peninsula of Michigan, USA with inset of upper Great Lakes. Yellow diamonds are sites (n = 2) with crossdated fire history for Sturgeon River Gorge study area, orange squares are sites (n = 5) with crossdated fire history for Huron Mountains study area, blue triangles are sites (n = 9) with crossdated fire history for Hiawatha National Forest West study area, green circles are sites (n = 50) with crossdated fire history for Seney National Wildlife Refuge study area, and black stars are sites (n = 2) with crossdated fire history for Hiawatha National Forest East study area.

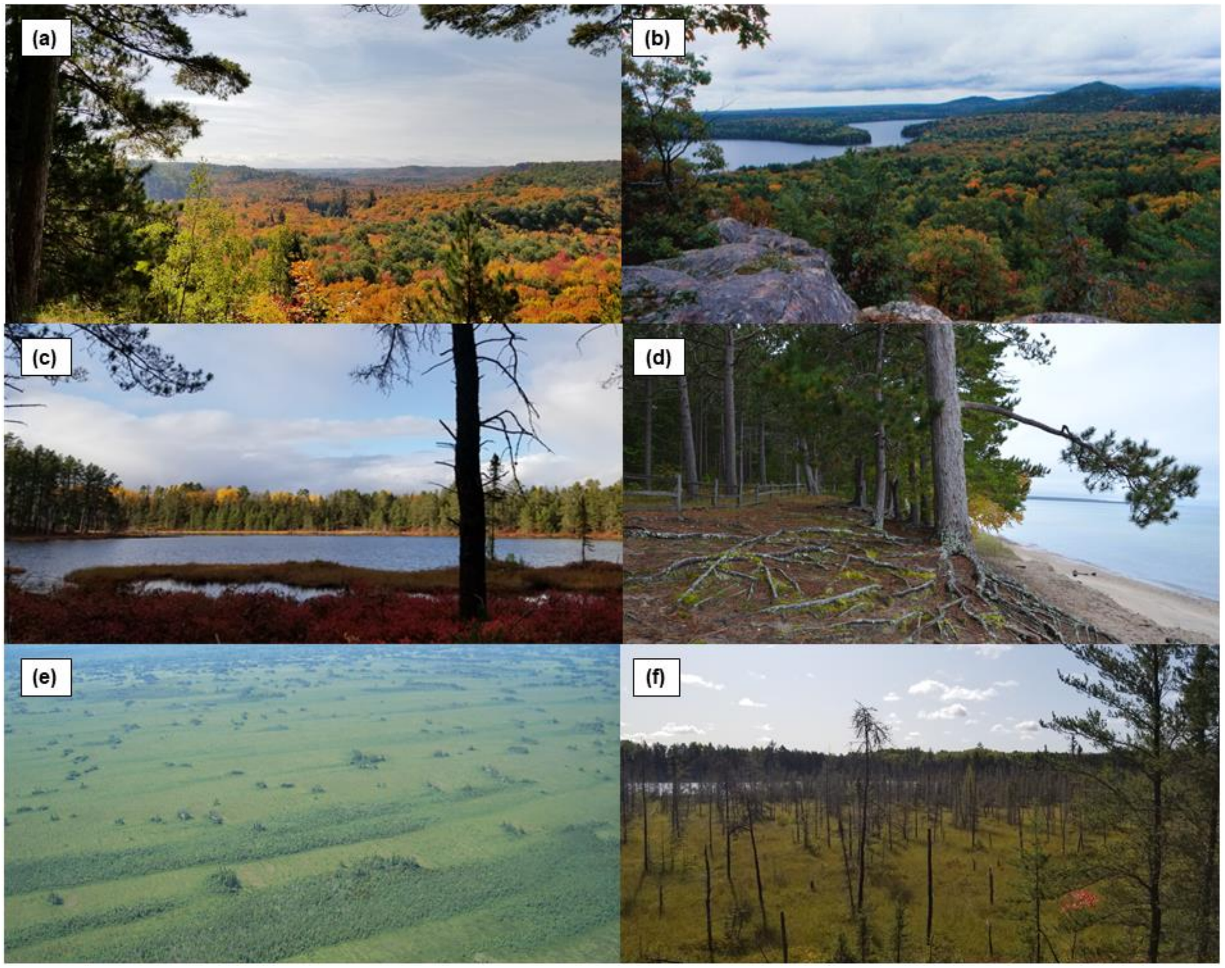

Fig. 6. Study areas across Upper Peninsula of Michigan, USA, depicting ecoregion vegetation types and landforms. (a) Sturgeon River Gorge in Keweenaw-Baraga Moraines ecoregion, northern hardwoods within gorge with mixed-pine forest atop ridges. (b) Pine Lake surrounded by Huron Mountains with red oak and red pine on exposed bedrock outcrops and northern hardwood forest typical of Michigamme Highland ecoregion. Image by D. Richler (c) Mixed-pine forest with scattered hardwoods on two sandy ridges extending alongside a shallow lake in Hiawatha National Forest West characteristic of interior Grand Marais Lakeshore ecoregion. (d) Red pines on sandy dune along Lake Superior in Hiawatha National Forest East typical of shorelines in the Grand Marais Lakeshore ecoregion. (e) Strangmoor Bog, a patterned fen in Seney National Wildlife Refuge, characteristic of extensive peatlands with mixed-pine ridges and islands of the Seney-Tahquamenon Sand Plain ecoregion. Photo courtesy of E. Brosnan (f) Transverse dune complex adjacent to Upper Lost Lake in Hiawatha National Forest West with mixed-pine ridges and peatlands, characteristic of the Seney-Tahquamenon Sand Plain ecoregion.

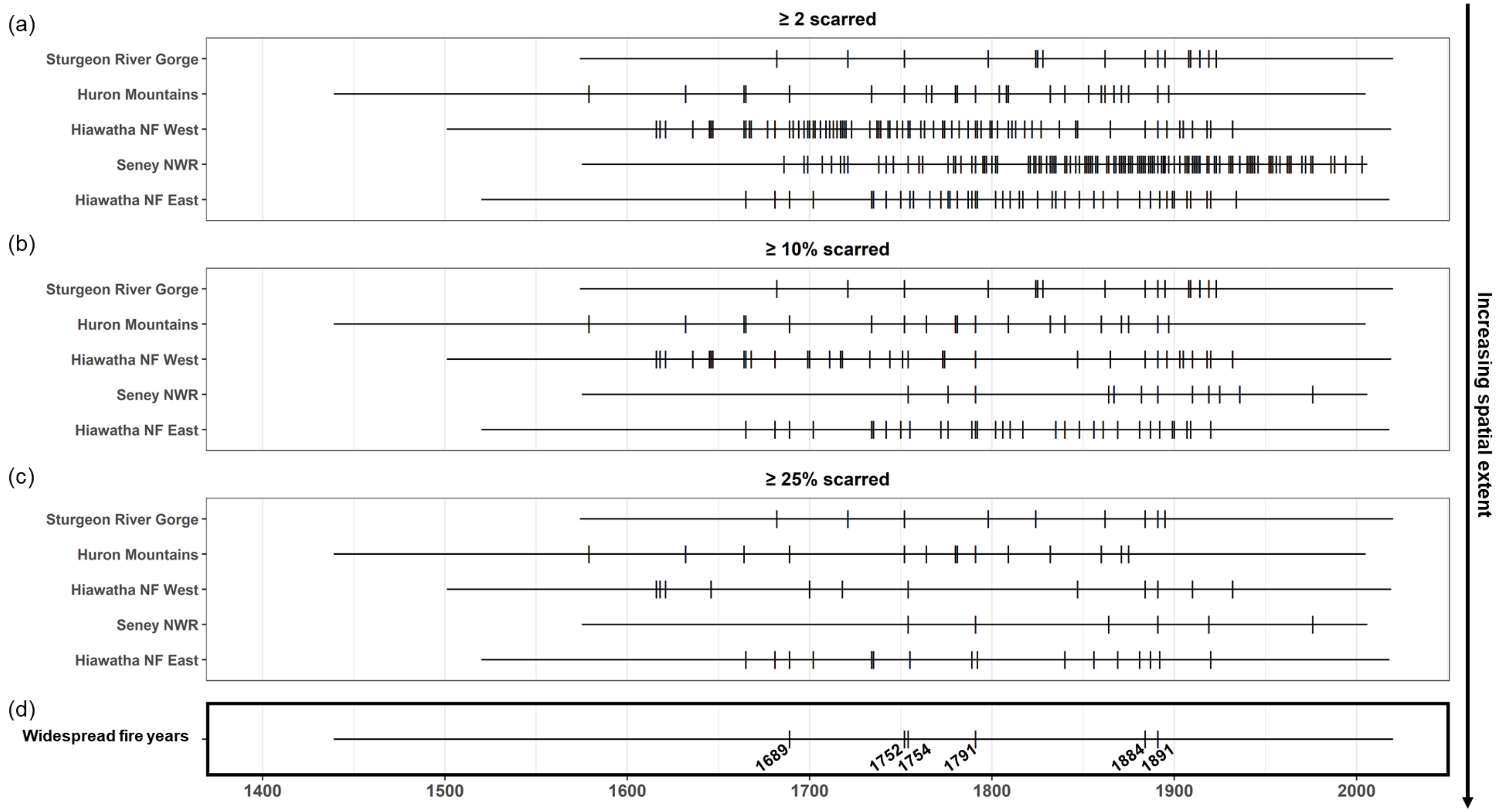

Fig. 7. Composite fire histories of 5 study areas in Upper Peninsula of Michigan, USA arranged from top to bottom by increasing spatial extent of composited fire events. Horizontal lines represent composited fire histories for each study area with fire events (vertical ticks) filtered by relative spatial extent. (a) Composited fire events that scarred ≥ 2 samples and correspond to smaller fires. (b) Composited fire events that scarred ≥ 2 samples and 10% of samples and correspond to moderate fires. (c) Composited fire events that scarred ≥ 2 samples and 25% of samples and correspond to large fires. (d) Widespread fire years included fire events that scarred ≥25% of samples within individual study areas and were recorded at ≥ 2 study areas.

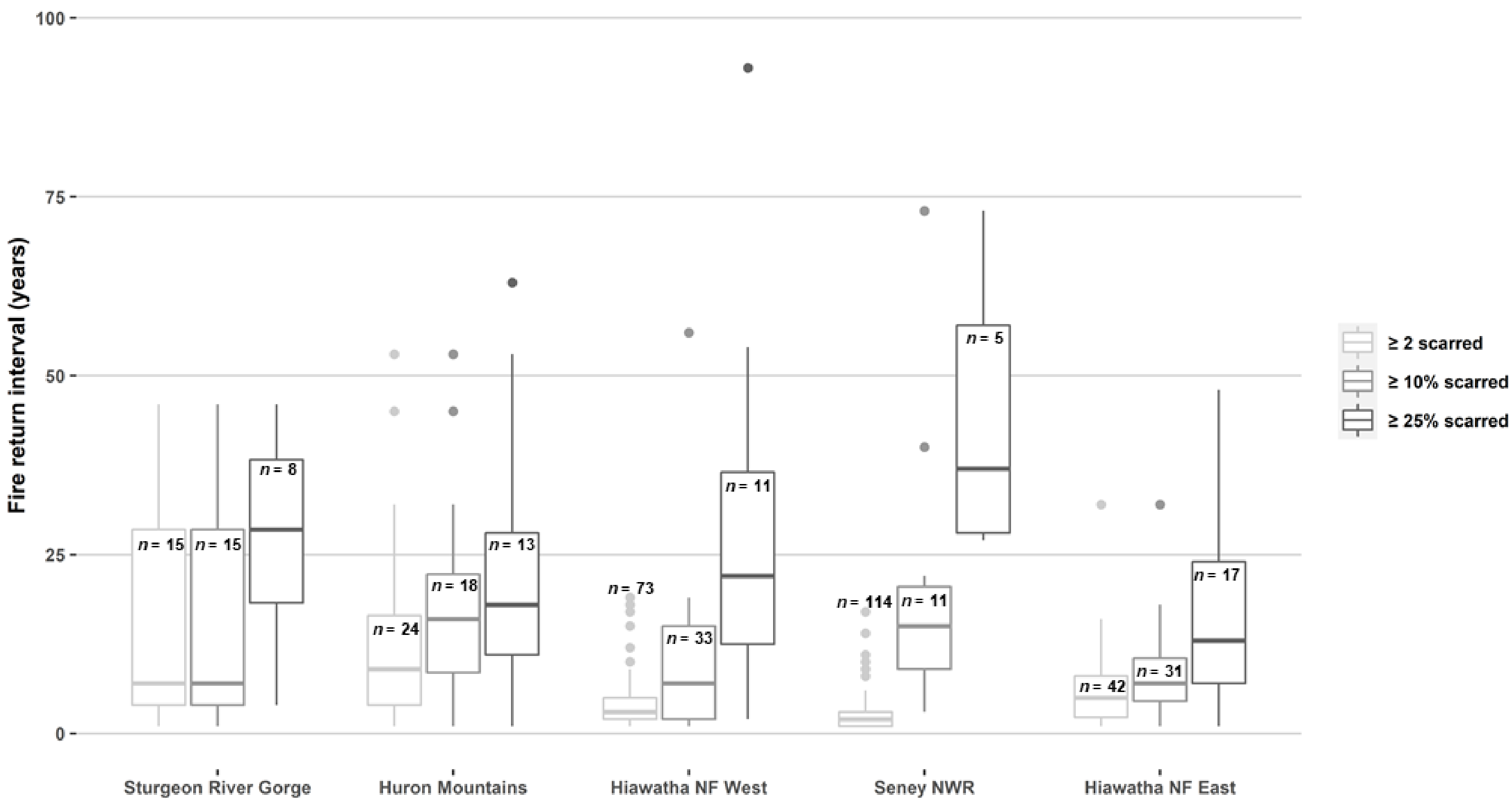

Fig. 8. Boxplots showing the variability of fire return intervals (years) for fires of small, moderate, and large extents within each of five study areas across the Upper Peninsula of Michigan, USA. The horizontal lines within each boxplot represent median fire return interval. Each box bounds the second and third quartiles of fire return intervals of a particular size range. The whiskers represent the lowest and highest fire return intervals within 1.5 times the interquartile range, with outliers marked by filled circles. Number of fire return intervals (n) is labeled for each box. Light gray boxplots indicate fire events that scarred ≥ 2 samples, medium gray indicates fire events that scarred ≥ 2 samples and 10% of samples, and black indicates fire events that scarred ≥ 2 samples and 25% of samples.

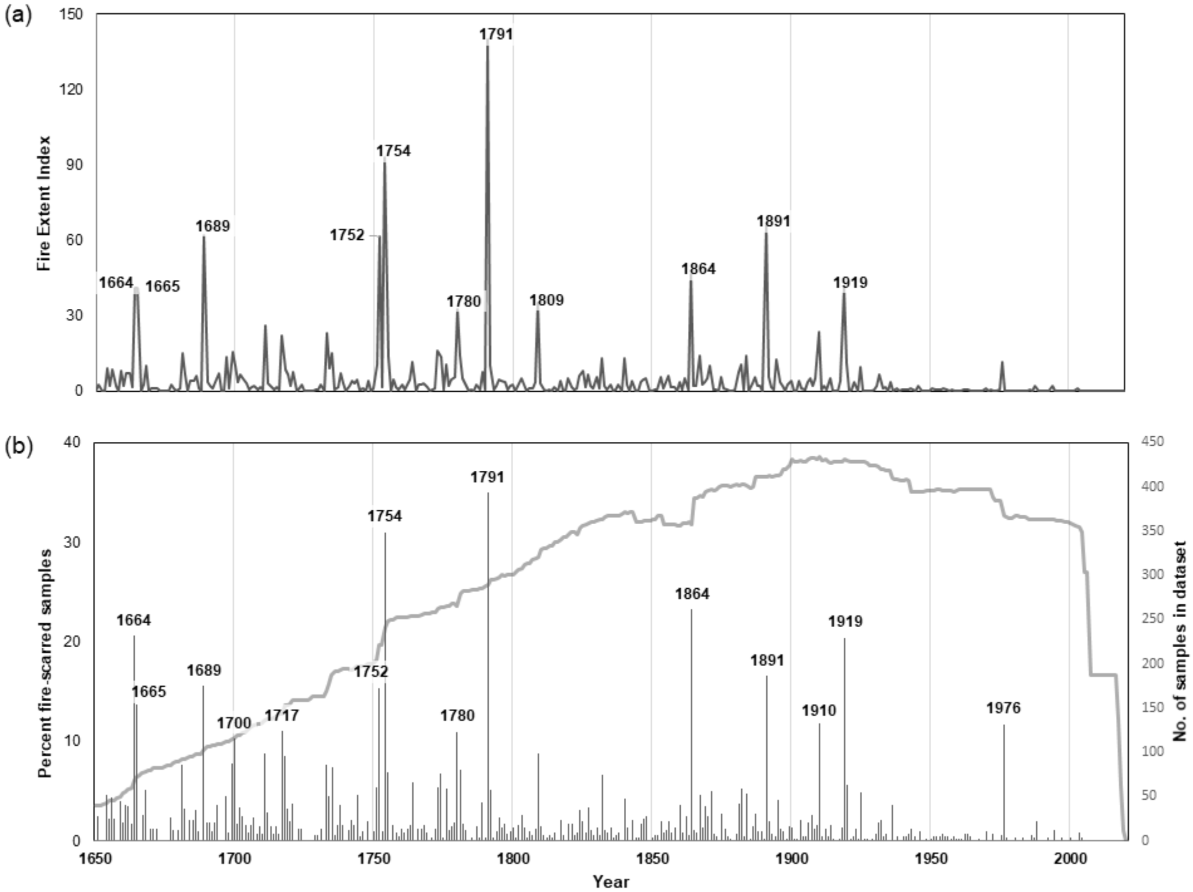

Fig. 9. Widespread fire years from 1650 to 2020. (a) Widespread fire years are indicated by largest values of fire extent index. Fire extent index for each year is the product of the number of study areas recording a fire in each year and the percent fire-scarred samples in each year. (b) Widespread fire years indicated by greatest percentage of fire-scarred samples, relative to all samples recording in that year. The left axis indicates the percent-fire scarred samples in each year and the right access indicates sample depth (total number of samples in the dataset in each year) as a continuous line.

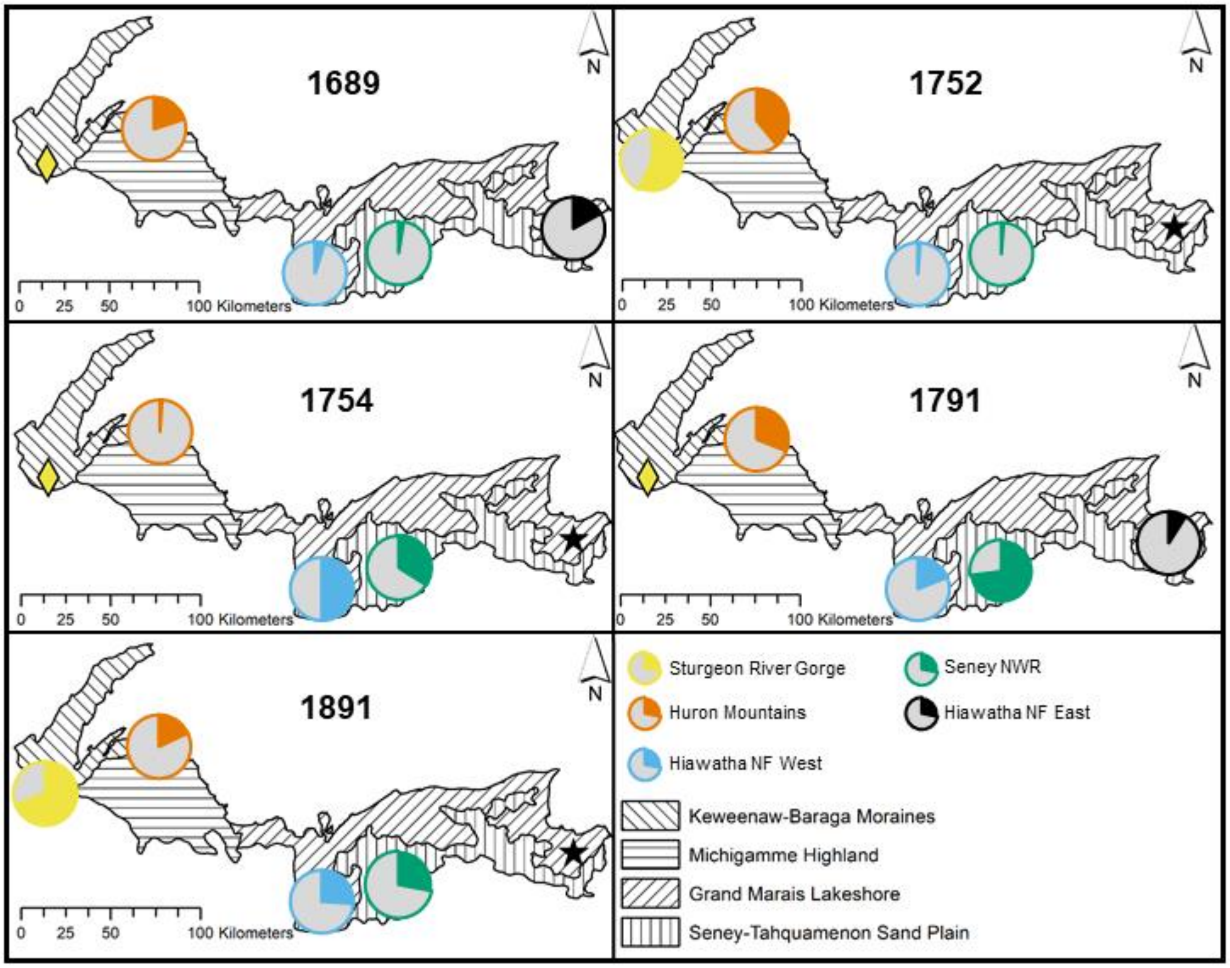

Fig. 10. Extent of regionally significant widespread fire years across the Upper Peninsula of Michigan, USA. Each panel corresponds to a single year and separate pie charts positioned at the center of each study area indicate percent fire-scarred samples in the associated year. The absence of a pie chart indicates that study area did not record a particular fire year.

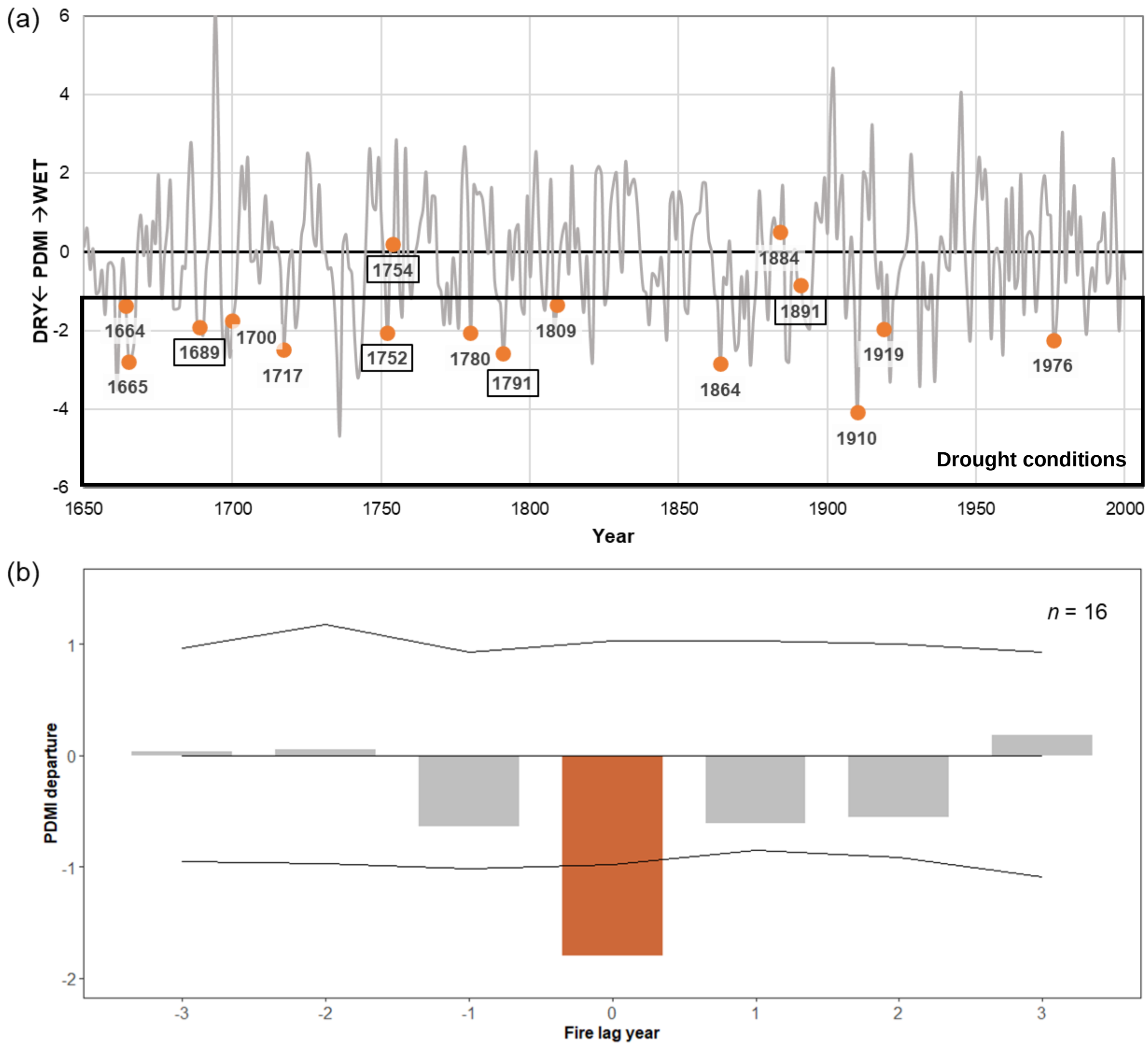

Fig. 11. Relating widespread fire years across upper Great Lakes Region to growing season (June–August) Palmer Modified Drought Index (PMDI; Cook *et al.* 2010), 1650 to 2000. Regionally significant fire years are outlined. (a) Time series of PMDI with widespread fire years among all study areas of the Upper Peninsula of Michigan. Colored circles indicate the most widespread fire years (n = 16) during the analysis period, determined as years with greatest FEI values, greatest percent-fire scarred samples, and fire events synchronous among study areas. Solid line corresponds to moving average of PMDI during the analysis period. Drought conditions occur when PMDI $\leq$ -1 (Palmer 1965). (b) Superposed epoch analysis (SEA) comparing widespread fire years, two years prior, and two years after from average PMDI across the upper Great Lakes Region for the 16 widespread fires indicated in (a). Horizontal solid lines indicate the 95% confidence interval in annual variability in growing season PMDI. Orange-shaded bars indicate years in which there is a significant departure ($p < 0.05$) from average growing PMDI. n = number of widespread fire years used in SEA.

Appendix A. Sensitivity analyses of major conclusions from chapter 1 by assigning ring-boundary scars to the previous year

In chapter 1, we followed the convention of assigning ring-boundary scars (dormant season position) to the year containing the earlywood immediately following fire scars (Muzika et al. 2015, Johnson and Kipfmueller 2016, Meunier et al. 2019). However, we recognize that seasonality of dormant-season fire scars is unresolved in the upper Great Lakes Region. Indeed, we observed a preponderance of back-to-back fire years (Table A1), suggesting any blanket rule of assigning all dormant fires as spring or fall season may be problematic in fire histories. This is especially true in peatlands where fires may burn throughout the fall, winter, and into the following spring (Scholten et al. 2021).

To investigate if dormant fire scar year assignment substantially affected our major conclusions about fire regimes in hemiboreal peatlands, we conducted sensitivity analyses (Table A2, Table A3, Fig. A1, and Fig. A2) in which we assigned the year of within-ring dormant fire scars to the previous year rather than the following year. When we did so, all of our major conclusions remained the same. We found that low-severity fire events were frequent and widespread, and that fire years did not occur during severe regional drought but occurred during moderate drought conditions, regardless of the year dormant fire scars (143 out of 413 total fire scars) were assigned to.

Table A1. Percentages of fire scars in back-to-back fire years identified to dormant, earlywood, and latewood positions within tree rings and fire scars in back-to-back fire years where ring position was not determined. There was no occurrence of predominantly latewood or earlywood fire scars across these back-to-back years that would support a blanket rule of assigning dormant fire scar year to the previous or subsequent year.

Back-to-back year	Site	Unknown fires scars	Dormant fire scars	Earlywood fire scars	Latewood fire scars
Previous year	Haymeadow Flowage	–	1.1%	–	–
	Ramsey Lake	0.8%	–	–	–
	Betchler Lake	4.7%	4.2%	–	5.8%
Subsequent year	Haymeadow Flowage	–	2.2%	–	–
	Ramsey Lake	–	–	–	0.8%
	Betchler Lake	8.4%	11.6%	–	1.1%

Notes: Percentages were determined out of total number of fire scars at each site: Haymeadow Flowage (*n* = 91), Ramsey Lake (*n* = 132), and Betchler Lake (*n* = 190). Dormant corresponds to fire scars occurring between the latewood and earlywood ring margins and is assigned to the following earlywood year. Earlywood corresponds to fire scars occurring at any position (early, middle, or late) in the earlywood portion of the tree ring. Latewood corresponds to fire scars occurring at latewood positions in the tree ring.

Table A2. Mean fire return intervals (MFRI) with dormant fire scars assigned to the previous year among hemiboreal peatlands of the upper Great Lakes Region.

Site	Area sampled(ha)	Crossdated samples	No. fire years	All fires MFRI(yr)	10% MFRI(yr)	25% MFRI(yr)	Landscape MFRI(yr)	Time span (yrs)
Haymeadow Flowage	210	26	34	6	7	18	10	1784–1944
Ramsey Lake	930	41	49	14	18	22	25	1637–1932
Betchler Lake	1220	62	83	9	14	27	21	1547–1954

Notes: Number of fire years corresponds to all years with fire events regardless of number of samples scarred. Mean fire return intervals (MFRI) were estimated only for fire events occurring on at least two samples. Successive filtering (e.g., fire years occurred on ≥ 10% of fire-scarred samples and fire years occurred on ≥ 25% of fire-scarred samples) identifies more widespread fire events. Landscape mean fire return intervals were estimated for fire years recorded on more than two forested uplands within and surrounding peatlands. Time span corresponds to span between first and last fire year.

Table A3. Percentages of fire years with dormant fire scars assigned to the previous year in corresponding drought conditions (Palmer 1965) among hemiboreal peatlands of the upper Great Lakes Region with dormant fire scars assigned to the previous year.

Drought condition	All fire years	10% scarred fire years	25% scarred fire years	Landscape fire years
Wetter, near normal, incipient drought	64.5%	63.6%	60.9%	52.2%
Mild and moderate drought	30.7%	31.8%	34.8%	47.8%
Severe and extreme drought	4.8%	4.6%	4.3%	0.0%

Notes: All fire years are years with fire events on at least two samples. Filtering (e.g., fire year occurred on ≥ 10% of fire-scarred samples and fire year occurred on ≥ 25% of fire-scarred samples) at the landscape scale identifies more widespread fire events. Landscape fire years are fire events recorded on > two forested uplands within and surrounding peatlands. Drought conditions are designations from Palmer 1965 with wetter, near normal, and incipient drought corresponding to PDSI ≥ -0.49, mild and moderate drought corresponding to -2.99 ≤ PDSI ≤ -0.50, and severe and extreme drought PDSI ≤ -3.00.

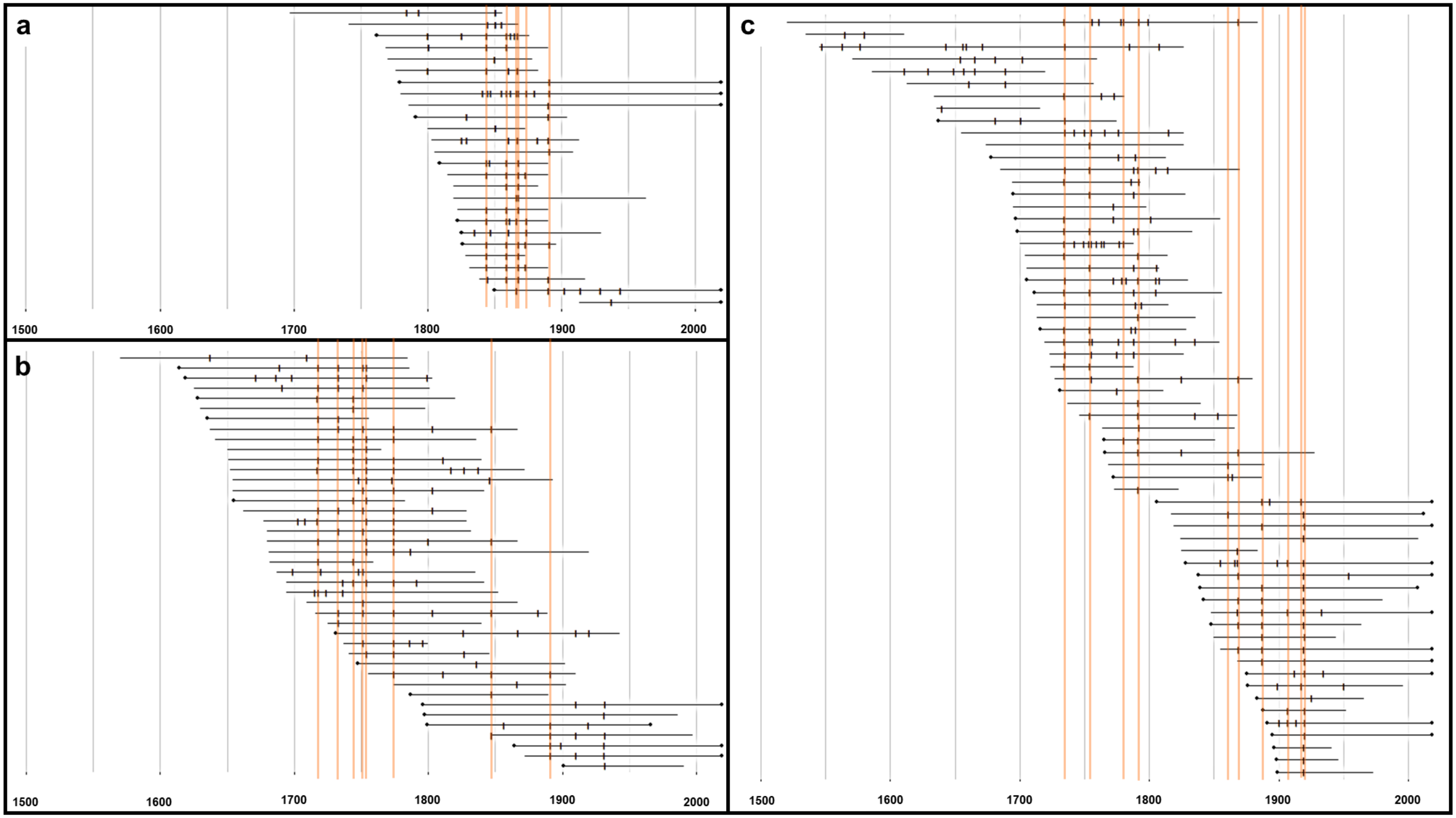

Fig. A1. Fire histories with dormant fire scars assigned to the previous year for three hemiboreal peatlands across the upper Great Lakes Region arranged by site. (a) Haymeadow Flowage, (b) Ramsey Lake, and (c) Betchler Lake. Each horizontal line is a sample (remnant stump, standing snag, fallen snag, or living tree), black vertical lines are recorded fire events, and black circles are pith/bark years. Orange vertical lines highlight years where fire events were recorded on more than two forested uplands within and surrounding peatlands representing widespread fire years.

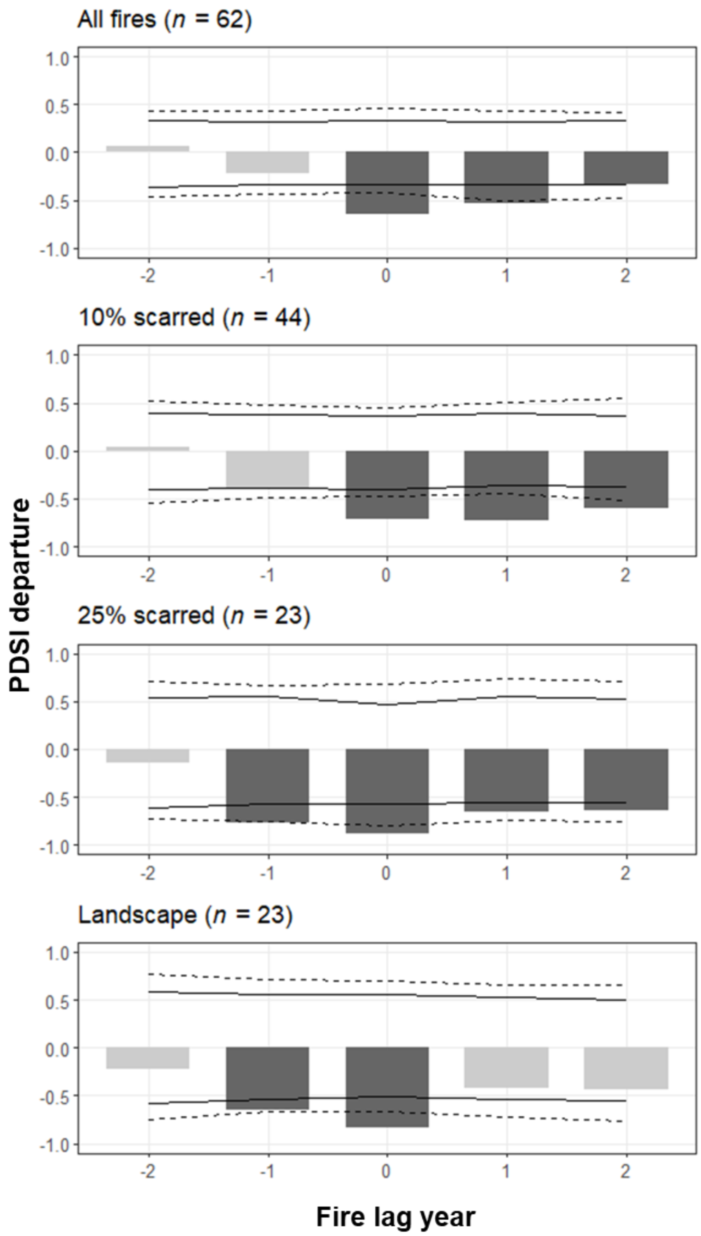

Fig. A2. Superposed epoch analyses of departure from average summer Palmer Drought Severity Index (PDSI; Cook et al. 2007, Malevich et al. 2018) across the upper Great Lakes Region during fire years with dormant fire scars assigned to the previous year. Fire years included years detected among the three hemiboreal peatland sites for all fire events recorded on at least two samples, fire events recorded ≥ 10% of samples, ≥ 25% samples, and fire events that occurred on more than two forested uplands within and surrounding peatlands at each site (Landscape). Positive PDSI indicate wet conditions and negative indicate dry conditions. Dark grey bars indicate a significant departure (p-value < 0.05) from average summer PDSI. Solid horizontal lines correspond to 95% confidence interval and dashed lines are 99% confidence interval.

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Appendix B. Site descriptions

ID	State	Property	Site	Description
BDO	MI	Sturgeon River Gorge Wilderness (Ottawa National Forest)	Bears Den Overlook	Site located past and along trail to scenic overlook point. Overstory mixture of hardwoods, PIST, and PIRE and understory of bracken fern, wintergreen, and wood bettany. Majority of stumps on south facing slope contoured around wetland and facing gorge. Recent fire evident as well as fire scarred hemlock and white cedar present
PRT	MI	Sturgeon River Gorge Wilderness (Ottawa National Forest)	Pine Ridge Trail	Site located adjacent to trail that leads across ridge stretching into river gorge. Overstory hardwood and some PIRE with understory of sweet and bracken fern; majority of live Pire with 2 to 3 fire scars and an abundance of fire scarred stumps. Primarily sampled midslope
RALA	MI	Hiawatha National Forest (West Zone)	Ramsey Lake	Sandy ridges stretching to open and sprue dominated peatland; fern, wintergreen, vaccinium, and sedge understory with POGA/POGR and pine overstory; 3 shallow lakes scattered within peatlands between ridges including one with beaver hut; understory thick vaccinium and winter green with overstory of younger PIRE with older PIRE along edges; POGR and maple on high points in areas where recent management thick herbaceous layer with high bush cranberry young PIBA and young aspen Peatland (poor fen) generally floating sphagnum mats, cotton grass, and sedge with relatively little brush where open and heavily dominated by black spruce, bush cranberry, leatherleaf with some tamarack where closed
HEBL	MI	Hiawatha National Forest (East Zone)	Betchler Lake Uplands	Predominantly PIRE and PIBA with sparse understory of bracken fern, vaccinium, wintergreen, occasionally sedge
BLPL, BLPLE	MI	Hiawatha National Forest (East Zone)	Betchler Lake Peatlands	Very open with pockets of spruce and tamarack saplings most dense along edges; predominantly sedge with prevalence of Eriophorum(cottongrass) and sphagnum; small lakes interspersed in peatland; pitcher plants present in open areas of sedge; leatherleaf and bog birch present and abundant in some areas; Labrador tea also locally abundant in some places generally near island and upland margins
HEBV	MI	Hiawatha National Forest (East Zone)	Bayview Day Use Area	Dry site predominantly PIRE plantation with fern understory; directly adjacent to Lake Superior; very sandy soil with vaccinium abundant and history of recent fire as seen by fire scarred living trees

ID	State	Property	Site	Description
HAFL	WI	Chequamegon-Nicolet National Forest	Haymeadow Flowage	Uplands: To north of Haymeadow Flowage PIRE dominant with PIST and hardwood interiors; understory dense in center and up high and this out along sloped edge into flowage; fern and sapling understory/ To south of Haymedow Flowage: PIRE plantation origin 1985; Super canopy PIRE with midstory maple; understory hardwood saplings and hazel with some bracken fern Islands: Multicohort PIRE islands with understory of fern and wintergreen; islands with younger PIRE thick with black spruce saplings and some white pine; vaccinium and labrador tea thick around boarders of islands in peatland; catfaces on islands face in different directions facing away from peatland;Triangle island in middle of flowage Jack pine dominant around periphery with a few open grown PIST and PIRE; vaccinium and fern dominate middle of island pure herbaceous ground cover Peatland (northern poor fen) relatively open in center sphagnum, sedge, bush cranberry and leather leaf with pockets of black spruce

Appendix C. Fire-scarred samples metadata

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
BPO_FS1	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.05992	-86.85645	30.4	10	23	W	none
BPO_FS2	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.06003	-86.85629	40.7	10	36	W	none
BPO_FS3	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.06003	-86.85629	47	10	36	W	none
BPO_FS4	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.0599	-86.85626	30.2	30	23	W	none
BPO_FS5	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.06107	-86.85625	30	20	19	W	none
BPO_FS6	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.06112	-86.85642	69.4	10	20	W	none
BPO_FS7	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.06131	-86.85653	47	10	25	W	none
BPO_FS8	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.06159	-86.85674	45.4	20	29	W	none
BPO_FS9	MI	Big Pine Overlook	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.06186	-86.85677	50.7	20	20	W	none
HCL_FS15	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.1562	-86.58795	34.5	10	0	NA	none
HCL_FS1	MI	Corner Lake	JM, NH, AL, JL,	9/14/2017	PIRE	ST/ER	46.29229	-86.61629	22.3	37	0	NA	none

MR, SK, MS

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HCL_FS3	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15556	-86.58756	20.7	17	2	E	none
HCL_FS4	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15558	-86.58806	37.4	22	5	E	none
HCL_FS5	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15543	-86.58783	32.7	30	0	NA	none
HCL_FS6	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	SN/ER	46.1547	-86.58723	77	35	2	NE	none
HCL_FS7	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15473	-86.58718	51.9	10	0	NA	none
HCL_FS8	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15474	-86.58668	51.3	20	5	SW	none
HCL_FS9	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	LI	46.15472	-86.58607	60.1	34	6	E	none
HCL_FS10	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15431	-86.58644	40.5	15	0	NA	none
HCL_FS11	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15434	-86.58305	66.8	13	0	NA	none
HCL_FS12	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15359	-86.5854	41.3	12	0	NA	NW
HCL_FS13	MI	Corner Lake	JM, NH, AL, JL,	9/14/2017	PIRE	SN/ER	46.15361	-86.58549	63.3	20	0	NA	none

MR, SK, MS

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HCL_FS16	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/15/2017	PIRE	ST/ER	46.15559	-86.58875	31.2	10	0	NA	none
HCL_FS17	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/16/2017	PIRE	LI	46.1524	-86.58649	64.4	20	0	NA	E
HCL_FS18	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/17/2017	PIRE	ST/ER	46.15217	-86.58671	34.2	10	0	NA	none
HCL_FS19	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.15194	-86.58755	39	10	0	NA	none
HCL_FS20	MI	Corner Lake	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.1518	-86.58739	38.4	10	0	NA	none
CL_FS1	MI	Crooked Lake	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.21502	-86.38582	64.4	30	0	NA	none
CL_FS2	MI	Crooked Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.21518	-86.38579	59.3	30	0	NA	none
CL_FS3	MI	Crooked Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.21518	-86.38579	70.1	30	0	NA	none
CL_FS4	MI	Crooked Lake	JM, NH, AL, JL, MR, SK, MS	9/22/2017	PIRE	ST/ER	46.21564	-86.38644	38	10	0	NA	none
CL_FS5	MI	Crooked Lake	JM, NH, AL, JL, MR, SK, MS	9/23/2017	PIRE	ST/ER	46.21566	-86.38673	76.3	10	0	NA	none

EL_FS1	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	LI	46.11776	-86.43813	54.7	5	5	NW	120

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
EL_FS3	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.1185	-86.43798	61	10	13	W	288
EL_FS4	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.11877	-86.43781	41	5	0	NA	330/140
EL_FS5	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.1198	-86.43821	37.3	15	12	SW	44
EL_FS6	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.11994	-86.43877	67	10	16	SW	136
EL_FS7	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.12015	-86.43872	46.4		11	SW	none
EL_FS8	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.12023	-86.43912	21.8	5	8	SW	130
EL_FS9	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.11792	-86.43661	27.4	10	6	W	none
EL_FS10	MI	Eagle Lake	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.11798	-86.43324	55.3	10	0	NA	290
FO_FS1	MI	Fern and Onion Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.03841	-86.56367	52	10	0	NA	none
FO_FS2	MI	Fern and Onion Lake	JM, NH, AL, JL,	9/20/2017	PIRE	ST/ER	46.03833	-86.56371	52.6	18.5	0	NA	none

			MR, SK, MS										
FO_FS3	MI	Fern and Onion Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.03815	-86.56493	40.9	18	0	NA	none

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
FO_FS5	MI	Fern and Onion Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.03765	-86.56654	52.8	11	0	NA	none
FO_FS6	MI	Fern and Onion Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.0383	-86.56675	35.4		0	NA	none
FO_FS7	MI	Fern and Onion Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.0387	-86.56644	42.8	22	0	NA	none
FO_FS8	MI	Fern and Onion Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.0391	-86.568	64.8		0	NA	none
FO_FS9	MI	Fern and Onion Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.03898	-86.56798	27.5		0	NA	none
FO_FS10	MI	Fern and Onion Lake	JM, NH, AL, JL, MR, SK, MS	9/20/2017	PIRE	ST/ER	46.03869	-86.56441	41.1	10	0	NA	none
HP_FS1A	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.28978	-86.61562	50.2	20	0	NA	none
HP_FS1B	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.28978	-86.61562	50.2	10	0	NA	none
HP_FS2	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29037	-86.61607	48.9	10	0	NA	none

HP_FS3	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29025	-86.6167	45.3	15	0	NA	none
HP_FS4	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29023	-86.61675	61.4	5	0	NA	none

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HP_FS6	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29065	-86.61849	74.1	5	0	NA	none
HP_FS7	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29086	-86.6179	65.8	10	0	NA	none
HP_FS20	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.28992	-86.61893	52.1	15	0	NA	none
HP_FS8	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	SN/ER	46.29203	-86.61826	39.3	15	0	NA	none
HP_FS9	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29277	-86.61805	65.2	40	0	NA	none
HP_FS10	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29329	-86.61765	62.5	10	0	NA	SE
HP_FS11	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29354	-86.61748	43.6	73	0	NA	none
HP_FS12	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29357	-86.61752	46.6	5	0	NA	none
HP_FS13	MI	Hwy. 13 Plantation	JM, NH, AL, JL,	9/13/2017	PIRE	ST/ER	46.294	-86.61787	64.1	10	0	NA	none

			MR, SK, MS										
HP_FS14	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29411	-86.61799	68.6	5	0	NA	none
HP_FS16	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.28977	-86.617	29	10	0	NA	none

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HP_FS18	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.28948	-86.61797	71.8	15	0	NA	none
HP_FS19	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29079	-86.6187	51.2	10	0	SE	none
HP_FS21	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.28981	-86.61851	42.4	10	0	NA	none
HP_FS22	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.29258	-86.6192	69.2	10	0	NA	none
HP_FS23	MI	Hwy. 13 Plantation	JM, NH, AL, JL, MR, SK, MS	9/13/2017	PIRE	ST/ER	46.2938	-86.61968	52.8	10	0	NA	none
MC_FS1	MI	Murphy Creek	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	ST/ER	46.09159	-86.41391	60.1	20	0	NA	SE
MC_FS2	MI	Murphy Creek	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	ST/ER	46.09153	-86.41384	79.6	10	0	NA	none
MC_FS3	MI	Murphy Creek	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	ST/ER	46.09148	-86.41383	62	5	0	NA	S

MC_FS4	MI	Murphy Creek	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	ST/ER	46.09145	-86.41386	50.7	5	0	NA	E
MC_FS5	MI	Murphy Creek	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	ST/ER	46.10471	-86.42377	34.7	10	0	NA	none
MC_FS6	MI	Murphy Creek	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	ST/ER	46.1045	-86.42403	41.5	20	0	NA	none

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
NC1_FS1	MI	Native Camp 1	JM, NH, AL, JL, MR, SK, MS	9/11/2017	PIRE	ST/ER	45.82501	-86.96256	43.8	50	0	NA	290
ORV_FS1	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.1279	-86.47143	26.8	20	22	E	260
ORV_FS2	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.12793	-86.47159	40.3	30	19	E	240
ORV_FS3	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.12788	-86.4714	41.8	30	9	E	240
ORV_FS4	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.12809	-86.47069	35.2	20	9	SW	none
ORV_FS5	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/12/2017	PIRE	SN/ER	46.12815	-86.47074	23.3	30	16	SW	none
ORV_FS10	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.12741	-86.47054	30.8	15	12	W	none
ORV_FS11	MI	Off Road Valley	JM, NH, AL, JL,	9/19/2017	PIRE	ST/ER	46.12689	-86.4701	68.9	15	8	W	none

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
			MR, SK, MS										
ORV_FS12	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.1273	-86.47069	35.9	15	9	W	none
ORV_FS13	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.12606	-86.47012	20.5	30	20	NW	none
ORV_FS14	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.12629	-86.47129	56.4	20	12	E	none
ORV_FS16	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.12823	-86.47231	60.3	10	8	E	none
ORV_FS17	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.1261	-86.47177	23.1	10	0	NA	none
ORV_FS18	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.12606	-86.4718	26.8	15	0	NA	none
ORV_FS19	MI	Off Road Valley	JM, NH, AL, JL, MR, SK, MS	9/19/2017	PIRE	ST/ER	46.12622	-86.47163	27.6	10	6	NW	none
PL_FS20	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28134	-86.64976	60.5	10	15	N	S
PL_FS21	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28223	-86.65029	63.4	15	13	E	none
PL_FS22	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28246	-86.65044	48.7	20	8	E	none

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
PL_FS23	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28254	-86.6513	61.5	15	6	W	none
PL_FS1	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28103	-86.64954	42.2	10	0	NA	none
PL_FS2	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28107	-86.64952	51.8	10	0	NA	none
PL_FS3	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28123	-86.64909	52	10	0	NA	none
PL_FS5	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28183	-86.64893	37.2	10	0	NA	none
PL_FS6	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28199	-86.64936	51.5	10	0	NA	none
PL_FS7	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.2823	-86.64919	57.9	15	0	NA	none
PL_FS8	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28297	-86.64866	41.1	20	0	NA	none
PL_FS9	MI	Peck Lake	JM, NH, AL, JL, MR, SK, MS	9/21/2017	PIRE	ST/ER	46.28301	-86.64865	47.2	20	0	NA	none
STU_FS1	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19747	-86.4351	52.1	20	0	NA	none
STU_FS2A	MI	Steuben Lake	JM, NH, AL, JL,	9/18/2017	PIRE	ST/ER	46.19737	-86.43533	30.6	15	0	NA	none

			MR, SK, MS										
STU_FS2B	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19737	-86.43533	30.6	10	0	NA	none
STU_FS3	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19716	-86.43571	55.5	10	0	NA	none
STU_FS4	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19704	-86.43524	64.9	10	0	NA	none
STU_FS5	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19717	-86.4347	27.4	10	0	NA	none

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
STU_FS7	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19574	-86.43665	49.3	10	0	NA	none
STU_FS8	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19485	-86.43557	53.2	10	0	W	none
STU_FS9	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19408	-86.43613	49.2	10	0	NA	none
STU_FS10	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19366	-86.43263	41.3	10	0	SW	none
STU_FS11	MI	Steuben Lake	JM, NH, AL, JL, MR, SK, MS	9/18/2017	PIRE	ST/ER	46.19476	-86.43284	33	10	0	NA	none
SL_FS1	MI	Swan Lake	JM, NH, AL, JL, MR, SK, MS	9/14/2017	PIRE	ST/ER	46.15998	-86.58462	55	10	0	NA	293

HEBV_FS10	MI	Bayview	MS, JM, MH, CS	8/18/2018	PIRE	LI	46.45232	-84.75900	58.4	15	N/A	N/A	298
HEBV_FS12	MI	Bayview	MS, JM, MH, CS	8/18/2018	PIRE	ST/ER	46.45275	-84.75990	30.5	15	5	10	N/A
HEBV_FS15	MI	Bayview	MH, CS	8/18/2018	PIRE	ST/ER	46.45277	-84.75909	39.7	5	N/A	N/A	N/A
HEBV_FS16	MI	Bayview	MH, CS	8/18/2018	PIRE	ST/ER	46.45270	-84.75818	35.8	7	N/A	N/A	N/A
HEBV_FS17	MI	Bayview	MH, CS	8/18/2018	PIRE	ST/ER	46.45247	-84.75827	30.4	15	N/A	N/A	N/A
HEBV_FS18	MI	Bayview	MH, CS	8/18/2018	PIRE	ST/ER	46.45233	-84.75767	29.5	10	6	149	N/A
HEBV_FS19a	MI	Bayview	MH, CS	8/18/2018	PIRE	ST/ER	46.45187	-84.75814	52.9	15	N/A	N/A	N/A
HEBV_FS19b	MI	Bayview	MH, CS	8/18/2018	-	-	-	-	-	-	-	-	-
HEBV_FS2	MI	Bayview	MS, JM, MH, CS	8/18/2018	PIRE	ST/ER	46.44992	-84.76183	43.9	5	5	157	124
HEBV_FS20	MI	Bayview	MS, JM	8/18/2018	PIRE	ST/ER	46.45294	-84.76015	44.6	10	4	320	58
HEBV_FS21	MI	Bayview	MS, JM	8/18/2018	PIRE	ST/ER	46.45256	-84.76089	33.7	10	2	320	90
HEBV_FS22	MI	Bayview	MS, JM	8/18/2018	PIRE	ST/ER	46.45230	-84.76132	47.9	5	2	339	142
HEBV_FS23	MI	Bayview	MS, JM	8/18/2018	PIRE	ST/ER	46.45200	-84.76153	28.8	15	N/A	N/A	100
HEBV_FS24	MI	Bayview	MS, JM	8/18/2018	PIRE	ST/ER	46.45201	-84.76015	20.4	5	N/A	N/A	121
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HEBV_FS26	MI	Bayview	MS, JM	8/18/2018	PIRE	ST/ER	46.45233	-84.75870	37.9	5	N/A	N/A	355
HEBV_FS4	MI	Bayview	MS, JM, MH, CS	8/18/2018	PIRE	ST/ER	46.45050	-84.76205	42.2	10	3	132	N/A
HEBV_FS6	MI	Bayview	MS, JM, MH, CS	8/18/2018	PIRE	ST/ER	46.45051	-84.76051	29.6	10	3	132	N/A
HEBV_FS8	MI	Bayview	MS, JM, MH, CS	8/18/2018	PIRE	LI	46.45008	-84.76076	56.6	20	10	140	305
HEBL_FS10	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29871	-84.91029	50.5	10	N/A	N/A	N/A
HEBL_FS11	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29933	-84.91016	33.7	10	N/A	N/A	N/A
HEBL_FS12	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29952	-84.91026	23.9	10	N/A	N/A	N/A
HEBL_FS13	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIBA	ST/ER	46.30091	-84.91113	12.6	50	N/A	N/A	N/A
HEBL_FS14	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.30071	-84.91108	28.7	20	N/A	N/A	N/A
HEBL_FS15	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.30130	-84.90981	27.5	15	N/A	N/A	N/A
HEBL_FS16	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIBA	ST/ER	46.30131	-84.90987	19.1	10	N/A	N/A	N/A
HEBL_FS17	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.30138	-84.90989	42.8	10	N/A	N/A	N/A

HEBL_FS18	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.30145	-84.90998	37.7	15	N/A	N/A	N/A
HEBL_FS19a	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.30165	-84.91026	37	10	N/A	N/A	N/A
HEBL_FS19b	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	-	-	-	-	-	20	-	-	-
HEBL_FS1a*	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29406	-84.90498	84.7	10	N/A	N/A	N/A
HEBL_FS1b	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	-	-	-	-	-	-	-	-	-
HEBL_FS2	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29292	-84.90562	38.7	10	N/A	N/A	N/A
HEBL_FS20a	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.30118	-84.90923	71.6	20	N/A	N/A	N/A
HEBL_FS20b	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.30118	-84.90923	71.6	20	N/A	N/A	N/A
HEBL_FS29	MI	Betchler Lake	JM, CS, MH, MS	8/20/2018	PIRE	ST/ER	46.31723	-84.94327	48.9	10	N/A	N/A	3 pieces
HEBL_FS3	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29220	-84.90543	17.4	7	N/A	N/A	N/A
HEBL_FS30	MI	Betchler Lake	MS, CS	8/19/2018	PIRE	ST/ER	46.30078	-84.91323	2.2	20	N/A	N/A	N/A
HEBL_FS31	MI	Betchler Lake	MS, CS	8/19/2018	PIRE	ST/ER	46.30288	-84.91753	49.7	0	6	20	N/A
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HEBL_FS33	MI	Betchler Lake	MS, CS	8/19/2018	PIBA	ST/ER	46.30310	-84.92067	36.1	10	6	10	N/A
HEBL_FS34	MI	Betchler Lake	MS, CS	8/19/2018	PIRE	ST/ER	46.30305	-84.92162	50.6	10	8	12	N/A
HEBL_FS35	MI	Betchler Lake	MS, CS	8/19/2018	PIRE	ST/ER	46.30228	-84.92456	43.1	10	N/A	N/A	N/A
HEBL_FS36	MI	Betchler Lake	MS, CS	8/19/2018	PIRE	ST/ER	46.30225	-84.92426	48.9	10	N/A	N/A	N/A
HEBL_FS37	MI	Betchler Lake	MS, CS	8/19/2018	PIRE	ST/ER	46.30231	-84.92439	38.1	10	N/A	N/A	N/A
HEBL_FS38	MI	Betchler Lake	JM, CS	8/20/2018	PIBA	LI	46.29279	-84.90240	63.3	25	N/A	N/A	230
HEBL_FS39	MI	Betchler Lake	MS, CS	8/19/2018	PIRE	ST/ER	46.31679	-84.94382	61.3	10	N/A	N/A	N/A
HEBL_FS4	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29216	-84.90539	23.2	10	N/A	N/A	N/A
HEBL_FS40a	MI	Betchler Lake	MS, CS, MH, K	8/21/2018	PIRE	ST/ER	46.26616	-84.91500	35.1	50	N/A	N/A	N/A
HEBL_FS40b	MI	Betchler Lake	MS, CS, MH, K	8/21/2018	-	-	-	-	-	15	-	-	-
HEBL_FS41a	MI	Betchler Lake	JM	8/21/2018	PIRE	ST/ER	46.26630	-84.91486	44	40	7	290	N/A

HEBL_FS41b	MI	Betchler Lake	JM	8/21/2018	-	-	-	-	-	20	-	-	-
HEBL_FS42	MI	Betchler Lake	MS, CS, MH, K	8/21/2018	PIBA	ST/ER	46.26619	-84.91500	44	15	N/A	N/A	N/A
HEBL_FS43	MI	Betchler Lake	JM	8/21/2018	PIRE	ST/ER	46.26658	-84.91518	52.8	5	1	290	N/A
HEBL_FS44	MI	Betchler Lake	MS, CS, MH, K	8/21/2018	PIRE	ST/ER	46.26740	-84.91412	32.1	10	8	195	N/A
HEBL_FS45	MI	Betchler Lake	JM	8/21/2018	PIRE	ST/ER	46.26677	-84.91447	65.4	5	5	347	N/A
HEBL_FS5	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	LI	46.29131	-84.90622	67.1	8	N/A	N/A	N/A
HEBL_FS50	MI	Betchler Lake	MH, CS	8/22/2018	PIRE	ST/ER	46.31636	-84.92986	45.6	15	N/A	N/A	N/A
HEBL_FS51	MI	Betchler Lake	MH, CS	8/22/2018	PIRE	LI	46.31640	-84.92973	67.4	20	N/A	N/A	N/A
HEBL_FS52	MI	Betchler Lake	MH, CS	8/22/2018	PIRE	ST/ER	46.31590	-84.93138	62.1	25	N/A	N/A	N/A
HEBL_FS53	MI	Betchler Lake	MH, CS	8/22/2018	PIRE	ST/ER	46.26742	-84.91517	39.7	5	4	224	N/A
HEBL_FS54	MI	Betchler Lake	MH, CS	8/22/2018	PIRE	ST/ER	46.26721	-84.91489	39.3	10	N/A	N/A	N/A
HEBL_FS55	MI	Betchler Lake	MH, CS	8/22/2018	PIRE	ST/ER	46.26876	-84.91344	50.1	10	N/A	N/A	N/A
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HEBL_FS57	MI	Betchler Lake	MH, CS	8/22/2018	PIRE	ST/ER	46.26958	-84.91309	43.5	15	6	317	53
HEBL_FS6	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29150	-84.90671	14.2	15	N/A	N/A	N/A
HEBL_FS7	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29311	-84.90789	37.3	10	N/A	N/A	N/A
HEBL_FS8	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29306	-84.90793	38.7	10	N/A	N/A	N/A
HEBL_FS9	MI	Betchler Lake	MH, CS, JM, MS	8/16/2018	PIRE	ST/ER	46.29879	-84.90616	34.2	15	N/A	N/A	N/A
BLPL_FS1	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIST	LI	46.30874	-84.95007	84.5	76.2	26	95	292
BLPL_FS10	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	LI	46.30682	-84.95235	81.8	10	12	220	0
BLPL_FS11	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.30732	-84.95365	45.3	10	N/A	N/A	N/A

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
BLPL_FS12	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.30735	-84.95370	40.6	10	N/A	N/A	N/A
BLPL_FS13	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.30709	-84.95090	28.6	10	N/A	N/A	N/A
BLPL_FS14	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	SN/ER	46.30722	-84.95100	46	10	N/A	N/A	N/A
BLPL_FS15	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.30675	-84.95073	22.8	10	3	223	N/A
BLPL_FS16	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.30640	-84.94997	40.2	20	10	225	N/A
BLPL_FS17	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	SN	46.30103	-84.94579	11.9	20	N/A	N/A	94
BLPL_FS18	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	LI	46.30169	-84.94146	69.3	10	N/A	N/A	104
BLPL_FS19a	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIBA	SN/BA	46.30183	-84.94176	24.4	50	N/A	N/A	186
BLPL_FS19b	MI	Betchler Lake Peatland	MH, JM	8/19/2018	-	-	-	-	-	50	-	-	-
BLPL_FS20	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIBA	SN/BA	46.30183	-84.94176	23	15	N/A	N/A	195
BLPL_FS21	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIBA	LI	46.29949	-84.94322	43.7	15	10	258	78
BLPL_FS22	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIBA	SN/ER	46.29929	-84.94299	36	10	23	270	N/A
BLPL_FS23	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.29819	-84.94346	55.9	10	11	67	N/A
BLPL_FS24	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	SN/ER	46.29757	-84.94302	25.9	10	10	348	N/A
BLPL_FS25	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.29750	-84.94314	44	20	10	316	N/A

BLPL_FS26	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIBA	LI	46.29829	-84.94358	40.7	50	10	340	85
BLPL_FS27	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.29888	-84.94466	44.2	10	11	240	N/A
BLPL_FS28	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIBA	SN/ER	46.30075	-84.95245	24.6	20	N/A	N/A	180
BLPL_FS3	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	SN/ER	46.30851	-84.95036	23.2	50	13	203	N/A
BLPL_FS30	MI	Betchler Lake Peatland	JM, CS, MH, MS	8/20/2018	PIBA	LI	46.30218	-84.95485	40.5	15	11	217	87
BLPL_FS31	MI	Betchler Lake Peatland	JM, CS, MH, MS	8/20/2018	PIBA	LI	46.30207	-84.95467	16.2	30	9	200	100
BLPL_FS32a	MI	Betchler Lake Peatland	JM, CS, MH, MS	8/20/2018	PIRE	SN/ER	46.30209	-84.95482	51	5	11	240	N/A
BLPL_FS32b	MI	Betchler Lake Peatland	JM, CS, MH, MS	8/20/2018	-	-	-	-	-	0	-	-	-
BLPL_FS33	MI	Betchler Lake Peatland	JM, CS, MH, MS	8/20/2018	PIRE	ST/ER	46.30304	-84.95454	43.5	5	14	38	N/A
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
BLPL_FS34b	MI	Betchler Lake Peatland	JM, CS, MH, MS	8/20/2018	-	-	-	-	-	5	-	-	-
BLPL_FS4	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	SN/ER	46.30852	-84.95024	27	50	13	203	N/A
BLPL_FS5	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIBA	LI	46.30859	-84.95077	22.2	10	14	192	N/A
BLPL_FS6	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	LI	46.30671	-84.95095	61.2	10	10	206	50
BLPL_FS7	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.30674	-84.95122	18.7	10	10	206	N/A
BLPL_FS8	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	ST/ER	46.30674	-84.95122	24	10	10	206	N/A

BLPL_FS9	MI	Betchler Lake Peatland	MH, JM	8/19/2018	PIRE	SN/BA	46.30680	-84.95147	59	10	10	206	50
BLPLE_FS30	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIST	SN/ER	46.29021	-84.92333	23.3	20	1	209	85
BLPLE_FS31	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIST?	SN/ER	46.29165	-84.92479	18.7	10	6	278	N/A
BLPLE_FS32	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIST?	SN/ER	46.29172	-84.92471	22.7	50	7	211	N/A
BLPLE_FS33	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIRE?	ST/ER	46.29192	-84.92491	27.8	5	8	209	N/A
BLPLE_FS34	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIRE	ST/ER	46.29192	-84.92491	51.4	10	N/A	N/A	N/A
BLPLE_FS35	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIRE	ST/ER	46.29358	-84.92578	48.6	10	N/A	N/A	N/A
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
BLPLE_FS37a	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIRE	SN/ER	46.29441	-84.92104	27.4	40	N/A	N/A	205
BLPLE_FS37b	MI	Betchler Lake Peatland East	CS, MH	8/24/2018	PIRE	SN/ER	46.29441	-84.92104					
BLPLE_FS38	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIRE	ST/ER	46.29256	-84.92130	49.4	20	4	169	193
BLPLE_FS39	MI	Betchler Lake Peatland East	CS, MH	8/23/2018	PIRE	SN/ER	46.29291	-84.92096	27.7	20	8	329	123
RALA_FS1	MI	Ramsey Lake	J. Meunier,	9/24/2019	PIRE	STER	45.98495	-86.78113	59	10	27	270	90

			C. Sutheimer										
RALA_FS2	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98518	-86.78152	35.5	10	27	270	NA
RALA_FS3a	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98531	-86.7814	37.5	50	28	275	NA
RALA_FS3b										10			
RALA_FS4	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98529	-86.78119	33	10	26	224	NA
RALA_FS5	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98525	-86.7812	32.5	10	26	224	305
RALA_FS6	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98509	-86.78109	33	10	12	170	180
RALA_FS7	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	SNER	45.98515	-86.79017	40	35	None	None	20
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
RALA_FS9	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98654	-86.78384	62	20	17	239	None
RALA_FS10	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98655	-86.78393	49	20	18	239	45

RALA_FS11	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98468	-86.77977	47	20	14	235	NA
RALA_FS12a	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98431	-86.77959	52.5	50	11	215	349
RALA_FS12b										10			
RALA_FS13	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98573	-86.77737	51	30	20	253	NA
RALA_FS14	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98514	-86.76961	82	20	8	65	NA
RALA_FS15	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/24/2019	PIRE	STER	45.98853	-86.76412	44	5	20	90	90
RALA_FS16a	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	SNER	45.9412	-86.80034	55	40	NA	NA	194
RALA_FS16b										36			
RALA_FS16c										20			
RALA_FS17	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	SNER	45.94147	-86.80019	16	10	NA	NA	NA
RALA_FS18	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER			31	10	NA	NA	NA

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
RALA_FS20	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.965	-86.76527	37	20	26	215	NA
RALA_FS21	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	LOER	45.96376	-86.76772	29	10	6.2	320	NA
RALA_FS22	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.96337	-86.76788	39	10	31	124	NA
RALA_FS23a	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.96313	-86.76795	56	50	23.2	139	NA
RALA_FS23b										10			
RALA_FS24	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.96323	-86.76823	36	10	20.3	174	NA
RALA_FS25	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.9632	-86.76846	30	10	13.1	177	NA
RALA_FS26	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.96315	-86.7704	56	10	16.7	195	NA
RALA_FS27	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.96371	-86.77101	30	30	24.8	30	164
RALA_FS28	MI	Ramsey Lake	J. Meunier, C.	9/25/2019	PIRE	STER	45.96397	-86.77219	37	15	25.8	218	43

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RALA_FS29	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.96397	-86.77214	33	15	27.5	18.7	NA
RALA_FS30	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	SNER	45.96567	-86.77917	44	60	13.6	217	NA

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
RALA_FS31b										40			
RALA_FS32	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	SNER	45.9683	-86.77367	35	40	NA	NA	157
RALA_FS33	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.96801	-86.77364	72	20	13	125	Multiple
RALA_FS34	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	SNER	45.96745	-86.77308	47	20	NA	NA	82
RALA_FS35	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/25/2019	PIRE	STER	45.96701	-86.7718	45	30	22.6	198	None
RALA_FS36a	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNER	45.99411	-86.77888	25	40	25.2	206	NA
RALA_FS36b										10			
RALA_FS37	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNER	45.99345	-86.77657	48	10	19.5	205	NA

RALA_FS38	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	STER	45.99345	-86.77648	47	20	25	225	47
RALA_FS39	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	STER	45.99345	-86.77561	30	5	12	202	NA
RALA_FS40	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNER	45.99053	-86.76815	30	50	0	0	NA
RALA_FS41	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNER	45.98908	-86.77044	50	60	7.9	147	NA

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
RALA_FS43	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	LOER	45.98895	-86.7709	20	20	21.8	182	NA
RALA_FS44	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNER	45.98906	-86.77335	36.5	5	19	214	NA
RALA_FS45	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNER	45.98916	-86.77361	49	10	14.5	223	NA
RALA_FS46	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNER	45.98926	-86.77425	38.5	30	21.7	212	NA
RALA_FS47a	MI	Ramsey Lake	J. Meunier, C.	9/26/2019	PIRE	SNER	45.98941	-86.77423	49	15	17.4	207	NA

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RALA_FS47b										10			
RALA_FS48	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNER	45.99026	-86.77731	33	20	18.2	192	NA
RALA_FS49	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNSA	45.99059	-86.77882	43.2	60	15.4	195	38
RALA_FS50	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	STER	45.99126	-86.78114	55	20	24.2	202	Multiple
RALA_FS51	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	SNBA	45.99139	-86.78135	10	20	NA	206	NA
RALA_FS52	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	STER	45.99094	-86.7839	46	20	NA	NA	125
RALA_FS53	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	LI	45.99089	-86.78408	57	60	1	17	344
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
RALA_FS55	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	STER	45.98948	-86.78239	45	10	30.8	221	64
RALA_FS56	MI	Ramsey Lake	J. Meunier, C. Sutheimer	9/26/2019	PIRE	LI	45.98934	-86.78223	55	45	16.4	220	100

RALA_FS57a	MI	Ramsey Lake	C. Sutheimer, I. Widick	10/10/2019	PIRE	SNER	45.98278	-86.76836	23.5	12	19.1	152	NA
RALA_FS57b										10			
RALA_FS58	MI	Ramsey Lake	C. Sutheimer, I. Widick	10/10/2019	PIRE	SNER	45.98298	-86.76797	28	10	30.9	153	NA
RALA_FS59	MI	Ramsey Lake	C. Sutheimer, I. Widick	10/10/2019	PIRE	SNER	45.98285	-86.76649	51	5	26.2	186	64
RALA_FS60	MI	Ramsey Lake	C. Sutheimer, I. Widick	10/10/2019	PIRE	STER	45.98222	-86.76346	25.5	5	7	6	NA
RALA_FS61	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/24/2019	PIRE	LI	45.98288	-86.76801	56.7	10	25.3	178	1
RALA_FS62	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/24/2019	PIRE	SNER	45.98188	-86.76407	45	0	NA	249	323
RALA_FS63	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/24/2019	PIRE	STER	45.97943	-86.76561	26.5	5	17	20	202
RALA_FS64a	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNER	45.98304	-86.78018	44.5	61	NA	NA	69
RALA_FS64b									46	30			
RALA_FS65a	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNER	45.98301	-86.77987	40	25	12.5	133	Multiple
RALA_FS65b									47	20			

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
RALA_FS66b										30			
RALA_FS67	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNER	45.97947	-86.77373	20	10	NA	NA	NA
RALA_FS68	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNBA	45.97977	-86.77416	20.5	40	13.5	72	253
RALA_FS69	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNER	45.98014	-86.77668	33	61	18.3	225	NA
RALA_FS70	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNER	45.9799	-86.77666	20.5	20	27.3	203	NA
RALA_FS71	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	STER	45.9809	-86.77875	42	10	17.4	229	50
RALA_FS72	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNBA	45.98281	-86.77423	20.5	20	17.3	183	326
RALA_FS73	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNER	45.98227	-86.77139	45	20	10.2	307	NA
RALA_FS74	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	STER	45.98217	-86.77149	46	5	20.5	185	351
RALA_FS75	MI	Ramsey Lake	J. Meunier, C.	10/25/2019	PIRE	SNER	45.98207	-86.77106	33	10	18	162	36

			Sutheimer										
RALA_FS76	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNER	45.98217	-86.77111	29.5	35	18	162	356
RALA_FS77	MI	Ramsey Lake	J. Meunier, C. Sutheimer	10/25/2019	PIRE	SNER	45.9822	-86.77107	22	76	18	162	344
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HAFL_FS1	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	LI	45.88047	-89.02384	50	60	11.6	228	134
HAFL_FS2	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.88148	-89.02367	26	50	20.8	318	105
HAFL_FS3	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.88146	-89.02356	30	10	NA	NA	NA
HAFL_FS4	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.88041	-89.0196	44.5	20	16.7	295	210
HAFL_FS5	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	LOER	45.87878	-89.0202	48	NA	NA	NA	NA
HAFL_FS6a	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	LOER	45.87902	-89.02	30.5	15	16.9	264	NA
HAFL_FS6b										10			

HAFL_FS7	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.87885	-89.02033	26	10	22.4	262	NA
HAFL_FS8	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	STER	45.87845	-89.02056	14	10	8.6	188	NA
HAFL_FS9	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.87825	-89.02011	24	15	15.4	259	NA
HAFL_FS10	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	LI	45.87805	-89.02017	21.5	10	5.3	283	NA
HAFL_FS11	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.87693	-89.0179	23.5	10	9.7	279	NA
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HAFL_FS13	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.87494	-89.01836	36	10	9	7.5	NA
HAFL_FS14	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	STER	45.87352	-89.01963	17	10	6.4	277	NA
HAFL_FS15	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.87263	-89.01987	30	15	15.2	163	NA
HAFL_FS16	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	LOER	45.87295	-89.01983	36	NA	NA	NA	NA

HAFL_FS17a	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	Missing	Missing	55	25	13.8	291	NA
HAFL_FS17b										20			
HAFL_FS18	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	LI	45.87984	-89.02406	47.5	35	11.6	47	220
HAFL_FS19	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.87978	-89.02411	38	30	22.2	19	358
HAFL_FS20	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.87981	-89.02416	47.5	20	13.3	19	329
HAFL_FS21	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	SNER	45.87977	-89.02425	12	20	16	326	NA
HAFL_FS22	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/7/2019	PIRE	LI	45.88056	-89.0238	46	13	13.1	337	151
HAFL_FS23	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.8676	-89.03951	33	15	19.4	196	0
ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HAFL_FS25	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.86785	-89.03944	46	20	17.9	188	336
HAFL_FS26	WI	Haymeadow Flowage	J. Meunier, C.	10/8/2019	PIRE	STER	45.86769	-89.03896	34	20	17.7	179	323

			Sutheimer										
HAFL_FS27	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.86945	-89.03707	46	20	25.3	120	344
HAFL_FS28	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.86989	-89.03673	33	10	10.3	107	Multiple
HAFL_FS29	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	LI	45.87093	-89.03587	54	30	NA	NA	270
HAFL_FS30a	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	SNER	45.87096	-89.0356	32	22	NA	NA	23
HAFL_FS30b										20			
HAFL_FS31a	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.87214	-89.0322	48	10	17.6	168	338
HAFL_FS31b													
HAFL_FS32	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	SNER	45.87214	-89.03225	21	15	22.5	150	NA
HAFL_FS33	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.87223	-89.03227	30	20	15.8	162	33
HAFL_FS34	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.87212	-89.032	34	10	23.8	172	8

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HAFL_FS36	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	LOER	45.87226	-89.03183	50	5	24.9	152	NA
HAFL_FS37	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.87238	-89.03088	26	5	23.4	167	NA
HAFL_FS38	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.87422	-89.02692	30	10	27.3	226	NA
HAFL_FS39	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIBA	STER	45.87384	-89.0265	28.5	20	17.8	222	NA
HAFL_FS40	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIBA	SNER	45.87356	-89.02615	10	25	6.4	213	NA
HAFL_FS41	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.8736	-89.02605	28	5	21.5	233	NA
HAFL_FS42	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.87342	-89.02586	20	10	23.7	225	NA
HAFL_FS43	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIBA	SNER	45.87328	-89.02564	17	5	20.8	235	355
HAFL_FS44	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.87312	-89.0254	24	5	16.5	242	NA

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
HAFL_FS45	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.87309	-89.02525	43	5	12.8	233	NA
HAFL_FS46	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	SNER	45.87188	-89.02522	45	2	11.5	315	NA
HAFL_FS48	WI	Haymeadow Flowage	J. Meunier, C. Sutheimer	10/8/2019	PIRE	STER	45.873	-89.02398	31	10	12.8	107	NA
HAFL_FS49	WI	Haymeadow Flowage	C. Sutheimer, I. Widick	10/9/2019	PIRE	LOER	45.86233	-89.01935	51	NA	5.2	303	NA
HAFL_FS50	WI	Haymeadow Flowage	C. Sutheimer, I. Widick	10/9/2019	THOC?	STER	45.86267	-89.01952	52	20	12.2	324	NA
HAFL_FS51	WI	Haymeadow Flowage	C. Sutheimer, I. Widick	10/9/2019	PIRE	SNER	45.87724	-89.02998	28	25	22.2	155	18
HAFL_FS52a	WI	Haymeadow Flowage	C. Sutheimer, I. Widick	10/9/2019	PIRE	SNER	45.87775	-89.02908	45	25	26.1	168	NA
HAFL_FS52b										20			
HAFL_FS53	WI	Haymeadow Flowage	C. Sutheimer, I. Widick	10/9/2019	PIRE	SNER	45.87361	-89.03085	57	20	10.5	79	NA
HAFL_FS54a	WI	Haymeadow Flowage	C. Sutheimer, I. Widick	10/9/2019	PIRE	SNER	45.86602	-89.02718	32	15	15.5	323	NA
HAFL_FS54b									38	10			

PBT_FS1	MI	Pine Bluff Trail	JM, CS	9/26/2020	PIRE	STER	46.60861111	-88.6616667	58	10	33.8	153	3
PBT_FS2	MI	Pine Bluff Trail	JR, AL, AM	9/26/2020	PIRE	SNER	46.60861111	-88.6633333	26	20	35	26	Upslope
PBT_FS3	MI	Pine Bluff Trail	JM, CS	9/26/2020	PIRE	STER	46.60833333	-88.6616667	36	10	29.7	146	252
PBT_FS4	MI	Pine Bluff Trail	JR, AL, AM	9/26/2020	PIRE	SNER	46.60861111	-88.6633333	28	40	35	15	Upslope
PBT_FS5	MI	Pine Bluff Trail	JM, CS	9/26/2020	PIRE	STER	46.60833333	-88.6622222	44	20	36.6	172	NA
PBT_FS6	MI	Pine Bluff Trail	JR, AL, AM	9/26/2020	PIRE	SNER	46.60833333	-88.6633333	39	40	35	10	Upslope
PBT_FS7	MI	Pine Bluff Trail	JM, CS	9/26/2020	PIRE	SNER	46.60861111	-88.6638889	28	5	34.3	235	38
PBT_FS8	MI	Pine Bluff Trail	JR, AL, AM	9/26/2020	PIRE	LOER	46.60861111	-88.6630556	32	40	35	35	Upslope
PBT_FS9	MI	Pine Bluff Trail	JM, CS	9/26/2020	PIRE	STER	46.60861111	-88.6594444	NA	NA	26.7	185	NA
PBT_FS10	MI	Pine Bluff Trail	JR, AL, AM	9/26/2020	PIRE	LI	46.60861111	-88.6633333	56	20	35	59	Upslope

ID	State	Site	Crew	Date	Species	Cond	X	Y	DSH(cm)	Height (cm)	Slope(°)	Aspect(°)	Cat Face(°)
BDO_FS1	MI	Bears Den Overlook	JM, CS	9/25/2020	PIRE	SNER	46.63916667	-88.6791667	16.3	30	41.4	160	NA
BDO_FS2	MI	Bears Den Overlook	JM, CS	9/25/2020	PIRE	SNER	46.63888889	-88.6791667	25	10	37.8	158	NA
BDO_FS3	MI	Bears Den Overlook	JM, CS	9/25/2020	PIRE	STER	46.63861111	-88.6783333	24.8	10	36.8	175	NA
BDO_FS4	MI	Bears Den Overlook	JM, CS	9/25/2020	PIRE	STER	46.63888889	-88.6783333	25.7	20	26.3	182	282
BDO_FS5	MI	Bears Den Overlook	JM, CS	9/25/2020	PIRE	STER	46.63888889	-88.6791667	37.1	10	27.7	155	NA
BDO_FS6	MI	Bears Den Overlook	JM, CS	9/25/2020	PIRE	LI	46.63888889	-88.6783333	43.5	20	38.1	148	352
BDO_FS7	MI	Bears Den Overlook	JM, CS	9/25/2020	PIRE	STER	46.63916667	-88.6777778	26.5	30	35.5	171	332
BDO_FS15	MI	Bears Den Overlook	JR, AM	9/25/2020	PIRE	SNER	46.63916667	-88.6791667	22	40	40	165	Upslope
BDO_FS16	MI	Bears Den Overlook	JR, AM	9/25/2020	PIRE	SNER	46.63888889	-88.6788889	28	60	40	190	Upslope
BDO_FS17	MI	Bears Den Overlook	JR, AM	9/25/2020	PIRE	LOER	46.63916667	-88.6794444	NA	NA	40	130	Upslope
BDO_FS18	MI	Bears Den Overlook	JR, AM	9/25/2020	PIRE	SNER	46.63972222	-88.6808333	30	30	3	335	Downslope

BDO_FS19	MI	Bears Den Overlook	JR, AM	9/25/2020	PIRE	SNER	46.63972222	-88.6811111	57	30	3	282	270
BDO_FS20	MI	Bears Den Overlook	JR, AM	9/25/2020	PIRE	STER	46.63916667	-88.6780556	23	25	40	355	Upslope

Appendix D. Fire-scarred samples fire history data
Betchler Lake

sample_ID	year	recorder type	sample_ID	year	recorder type
BLPL_FS3	1899	pith_year	BLPL_FS20	1848	pith_year
BLPL_FS3	1920	dormant_fs	BLPL_FS20	1869	unknown_fs
BLPL_FS3	1973	outer_year	BLPL_FS20	1887	latewd_fs
BLPLE_FS32	1898	pith_year	BLPL_FS20	1920	dormant_fs
BLPLE_FS32	1920	dormant_fs	BLPL_FS20	1964	outer_year
BLPLE_FS32	1946	outer_year	HEBL_FS5	1848	inner_year
BLPLE_FS31	1896	pith_year	HEBL_FS5	1869	dormant_fs
BLPLE_FS31	1920	dormant_fs	HEBL_FS5	1887	unknown_fs
BLPLE_FS31	1941	outer_year	HEBL_FS5	1907	unknown_fs
BLPL_FS5	1895	pith_year	HEBL_FS5	1920	dormant_fs
BLPL_FS5	1920	unknown_fs	HEBL_FS5	1934	dormant_fs
BLPL_FS5	2018	bark_year	HEBL_FS5	2018	bark_year
HEBL_FS51	1891	pith_year	BLPL_FS19	1842	pith_year
HEBL_FS51	1900	unknown_fs	BLPL_FS19	1869	unknown_fs
HEBL_FS51	1907	unknown_fs	BLPL_FS19	1887	unknown_fs
HEBL_FS51	1914	dormant_fs	BLPL_FS19	1920	dormant_fs
HEBL_FS51	1920	unknown_fs	BLPL_FS19	1980	outer_year
HEBL_FS51	2018	bark_year	BLPL_FS9	1839	pith_year
BLPL_FS24	1888	pith_year	BLPL_FS9	1887	unknown_fs
BLPL_FS24	1907	unknown_fs	BLPL_FS9	1920	dormant_fs
BLPL_FS24	1920	late_fs	BLPL_FS9	2007	bark_year
BLPL_FS24	1952	outer_year	BLPL_FS21	1838	pith_year
BLPL_FS17	1883	pith_year	BLPL_FS21	1869	unknown_fs
BLPL_FS17	1925	unknown_fs	BLPL_FS21	1920	dormant_fs
BLPL_FS17	1966	outer_year	BLPL_FS21	1955	dormant_fs
BLPL_FS28	1876	pith_year	BLPL_FS21	2018	bark_year
BLPL_FS28	1900	dormant_fs	HEBL_FS38	1828	pith_year
BLPL_FS28	1918	dormant_fs	HEBL_FS38	1855	unknown_fs
BLPL_FS28	1951	dormant_fs	HEBL_FS38	1866	unknown_fs
BLPL_FS28	1996	outer_year	HEBL_FS38	1869	dormant_fs
BLPL_FS26	1875	pith_year	HEBL_FS38	1900	dormant_fs
BLPL_FS26	1912	unknown_fs	HEBL_FS38	1907	unknown_fs
BLPL_FS26	1920	unknown_fs	HEBL_FS38	1920	dormant_fs
BLPL_FS26	1934	unknown_fs	HEBL_FS38	2018	bark_year
BLPL_FS26	2018	bark_year	HEBL_FS4	1825	inner_year
BLPL_FS30	1868	inner_year	HEBL_FS4	1869	dormant_fs
BLPL_FS30	1887	unknown_fs	HEBL_FS4	1884	outer_year
BLPL_FS30	1920	unknown_fs	BLPLE_FS35	1824	inner_year
BLPL_FS30	2018	bark_year	BLPLE_FS35	1920	dormant_fs
			BLPLE_FS35	2008	outer_year

Betchler Lake

sample_ID	year	recorder type	sample_ID	year	recorder type
BLPL_FS10	1855	inner_year	BLPL_FS18	1819	inner_year
BLPL_FS10	1869	unknown_fs	BLPL_FS18	1887	unknown_fs
BLPL_FS10	1887	unknown_fs	BLPL_FS18	1920	unknown_fs
BLPL_FS10	1920	dormant_fs	BLPL_FS18	2018	bark_year
BLPL_FS10	2018	bark_year	HEBL_FS32	1705	pith_year
BLPLE_FS36	1727	inner_year	HEBL_FS32	1735	unknown_fs
BLPLE_FS36	1755	unknown_fs	HEBL_FS32	1772	latewd_fs
BLPLE_FS36	1791	latewd_fs	HEBL_FS32	1779	latewd_fs
BLPLE_FS36	1825	unknown_fs	HEBL_FS32	1783	dormant_fs
BLPLE_FS36	1869	unknown_fs	HEBL_FS32	1792	dormant_fs
BLPLE_FS36	1880	outer_year	HEBL_FS32	1806	dormant_fs
HEBL_FS8	1724	inner_year	HEBL_FS32	1809	dormant_fs
HEBL_FS8	1734	latewd_fs	HEBL_FS32	1830	outer_year
HEBL_FS8	1755	dormant_fs	HEBL_FS45	1705	inner_year
HEBL_FS8	1788	outer_year	HEBL_FS45	1755	dormant_fs
HEBL_FS40	1723	inner_year	HEBL_FS45	1789	dormant_fs
HEBL_FS40	1735	unknown_fs	HEBL_FS45	1806	unknown_fs
HEBL_FS40	1755	unknown_fs	HEBL_FS45	1808	outer_year
HEBL_FS40	1775	unknown_fs	HEBL_FS12	1704	inner_year
HEBL_FS40	1789	dormant_fs	HEBL_FS12	1735	dormant_fs
HEBL_FS40	1827	outer_year	HEBL_FS12	1792	dormant_fs
HEBL_FS35	1719	inner_year	HEBL_FS12	1814	outer_year
HEBL_FS35	1734	latewd_fs	HEBL_FS43	1700	inner_year
HEBL_FS35	1755	dormant_fs	HEBL_FS43	1734	latewd_fs
HEBL_FS35	1757	dormant_fs	HEBL_FS43	1742	latewd_fs
HEBL_FS35	1776	unknown_fs	HEBL_FS43	1750	dormant_fs
HEBL_FS35	1789	dormant_fs	HEBL_FS43	1753	latewd_fs
HEBL_FS35	1820	unknown_fs	HEBL_FS43	1755	unknown_fs
HEBL_FS35	1835	unknown_fs	HEBL_FS43	1760	dormant_fs
HEBL_FS35	1854	outer_year	HEBL_FS43	1764	dormant_fs
HEBL_FS44	1716	pith_year	HEBL_FS43	1766	dormant_fs
HEBL_FS44	1734	latewd_fs	HEBL_FS43	1777	latewd_fs
HEBL_FS44	1755	dormant_fs	HEBL_FS43	1781	dormant_fs
HEBL_FS44	1787	dormant_fs	HEBL_FS43	1788	outer_year
HEBL_FS44	1789	unknown_fs	HEBL_FS41	1698	pith_year
HEBL_FS44	1829	outer_year	HEBL_FS41	1734	latewd_fs
HEBL_FS36	1713	inner_year	HEBL_FS41	1755	dormant_fs
HEBL_FS36	1792	dormant_fs	HEBL_FS41	1789	dormant_fs
HEBL_FS36	1836	outer_year	HEBL_FS41	1792	dormant_fs
			HEBL_FS41	1833	outer_year

Betchler Lake

sample_ID	year	recorder type
HEBL_FS57	1713	inner_year
HEBL_FS57	1735	unknown_fs
HEBL_FS57	1789	unknown_fs
HEBL_FS57	1795	dormant_fs
HEBL_FS57	1815	outer_year
HEBL_FS31	1613	inner_year
HEBL_FS31	1661	latewd_fs
HEBL_FS31	1689	unknown_fs
HEBL_FS31	1757	outer_year
HEBL_FS3	1586	inner_year
HEBL_FS3	1611	unknown_fs
HEBL_FS3	1629	unknown_fs
HEBL_FS3	1649	unknown_fs
HEBL_FS3	1657	unknown_fs
HEBL_FS3	1665	unknown_fs
HEBL_FS3	1689	unknown_fs
HEBL_FS3	1720	outer_year
BLPL_FS32	1571	inner_year
BLPL_FS32	1654	unknown_fs
BLPL_FS32	1665	unknown_fs
BLPL_FS32	1681	unknown_fs
BLPL_FS32	1702	unknown_fs
BLPL_FS32	1760	outer_year
HEBL_FS20	1545	inner_year
HEBL_FS20	1548	dormant_fs
HEBL_FS20	1563	unknown_fs
HEBL_FS20	1577	unknown_fs
HEBL_FS20	1643	unknown_fs
HEBL_FS20	1656	unknown_fs
HEBL_FS20	1660	dormant_fs
HEBL_FS20	1672	dormant_fs
HEBL_FS20	1735	unknown_fs
HEBL_FS20	1785	unknown_fs
HEBL_FS20	1808	unknown_fs
HEBL_FS20	1827	outer_year
BLPL_FS27	1535	inner_year
BLPL_FS27	1566	dormant_fs
BLPL_FS27	1580	unknown_fs
BLPL_FS27	1611	outer_year

sample_ID	year	recorder type
HEBL_FS34	1697	pith_year
HEBL_FS34	1735	dormant_fs
HEBL_FS34	1772	latewd_fs
HEBL_FS34	1802	dormant_fs
HEBL_FS34	1855	outer_year
BLPLE_FS34	1817	inner_year
BLPLE_FS34	1861	unknown_fs
BLPLE_FS34	1920	dormant_fs
BLPLE_FS34	2012	bark_year
BLPL_FS6	1806	pith_year
BLPL_FS6	1887	unknown_fs
BLPL_FS6	1893	unknown_fs
BLPL_FS6	1918	dormant_fs
BLPL_FS6	2018	bark_year
BLPLE_FS33	1773	inner_year
BLPLE_FS33	1791	latewd_fs
BLPLE_FS33	1823	outer_year
HEBL_FS19	1772	pith_year
HEBL_FS19	1861	unknown_fs
HEBL_FS19	1864	unknown_fs
HEBL_FS19	1887	outer_year
BLPL_FS34	1768	inner_year
BLPL_FS34	1861	unknown_fs
BLPL_FS34	1889	outer_year
BLPLE_FS37	1766	pith_year
BLPLE_FS37	1792	dormant_fs
BLPLE_FS37	1825	unknown_fs
BLPLE_FS37	1869	unknown_fs
BLPLE_FS37	1928	outer_year
BLPLE_FS39	1765	pith_year
BLPLE_FS39	1780	unknown_fs
BLPLE_FS39	1792	dormant_fs
BLPLE_FS39	1851	outer_year
BLPL_FS12	1764	inner_year
BLPL_FS12	1792	unknown_fs
BLPL_FS12	1866	outer_year
HEBL_FS2	1634	inner_year
HEBL_FS2	1735	dormant_fs
HEBL_FS2	1763	latewd_fs
HEBL_FS2	1773	unknown_fs
HEBL_FS2	1781	outer_year

Betchler Lake

sample_ID	year	recorder type	sample_ID	year	recorder type
HEBL_FS54	1695	pith_year	HEBL_FS56	1711	pith_year
HEBL_FS54	1755	dormant_fs	HEBL_FS56	1735	dormant_fs
HEBL_FS54	1789	dormant_fs	HEBL_FS56	1755	dormant_fs
HEBL_FS54	1828	outer_year	HEBL_FS56	1789	dormant_fs
HEBL_FS15	1694	inner_year	HEBL_FS56	1805	unknown_fs
HEBL_FS15	1735	dormant_fs	HEBL_FS56	1856	outer_year
HEBL_FS15	1787	dormant_fs	HEBL_FS50	1695	inner_year
HEBL_FS15	1792	unknown_fs	HEBL_FS50	1772	unknown_fs
HEBL_FS15	1793	outer_year	HEBL_FS50	1798	outer_year
HEBL_FS7	1685	inner_year	BLPL_FS31	1850	inner_year
HEBL_FS7	1735	unknown_fs	BLPL_FS31	1887	unknown_fs
HEBL_FS7	1755	dormant_fs	BLPL_FS31	1920	unknown_fs
HEBL_FS7	1789	dormant_fs	BLPL_FS31	1944	outer_year
HEBL_FS7	1792	dormant_fs	HEBL_FS1	1520	inner_year
HEBL_FS7	1806	dormant_fs	HEBL_FS1	1735	dormant_fs
HEBL_FS7	1815	dormant_fs	HEBL_FS1	1757	dormant_fs
HEBL_FS7	1870	outer_year	HEBL_FS1	1762	dormant_fs
HEBL_FS33	1678	pith_year	HEBL_FS1	1778	unknown_fs
HEBL_FS33	1776	unknown_fs	HEBL_FS1	1781	dormant_fs
HEBL_FS33	1790	dormant_fs	HEBL_FS1	1792	unknown_fs
HEBL_FS33	1813	outer_year	HEBL_FS1	1799	unknown_fs
HEBL_FS37	1674	inner_year	HEBL_FS1	1869	unknown_fs
HEBL_FS37	1755	dormant_fs	HEBL_FS1	1884	outer_year
HEBL_FS37	1827	outer_year	HEBL_FS42	1746	inner_year
HEBL_FS39	1655	inner_year	HEBL_FS42	1755	dormant_fs
HEBL_FS39	1735	unknown_fs	HEBL_FS42	1791	latewd_fs
HEBL_FS39	1742	unknown_fs	HEBL_FS42	1835	unknown_fs
HEBL_FS39	1750	unknown_fs	HEBL_FS42	1853	unknown_fs
HEBL_FS39	1755	unknown_fs	HEBL_FS42	1868	outer_year
HEBL_FS39	1766	unknown_fs	HEBL_FS11	1737	inner_year
HEBL_FS39	1776	unknown_fs	HEBL_FS11	1792	dormant_fs
HEBL_FS39	1815	unknown_fs	HEBL_FS11	1840	outer_year
HEBL_FS39	1827	outer_year	HEBL_FS52	1731	pith_year
HEBL_FS55	1637	pith_year	HEBL_FS52	1776	dormant_fs
HEBL_FS55	1681	latewd_fs	HEBL_FS52	1811	outer_year
HEBL_FS55	1702	dormant_fs	BLPL_FS16	1636	inner_year
HEBL_FS55	1735	unknown_fs	BLPL_FS16	1641	dormant_fs
HEBL_FS55	1775	outer_year	BLPL_FS16	1716	outer_year

Bayview

sample_ID	year	recorder type	sample_ID	year	recorder type
HEBV_FS10	1806	pith_year	HEBV_FS20	1780	inner_year
HEBV_FS10	1817	dormant_fs	HEBV_FS20	1802	dormant_fs
HEBV_FS10	1856	dormant_fs	HEBV_FS20	1810	dormant_fs
HEBV_FS10	1881	dormant_fs	HEBV_FS20	1817	latewd_fs
HEBV_FS10	1896	unknown_fs	HEBV_FS20	1828	latewd_fs
HEBV_FS10	1920	dormant_fs	HEBV_FS20	1830	latewd_fs
HEBV_FS10	2018	bark_year	HEBV_FS20	1879	outer_year
HEBV_FS8	1828	inner_year	HEBV_FS18	1807	pith_year
HEBV_FS8	1899	unknown_fs	HEBV_FS18	1833	dormant_fs
HEBV_FS8	1909	unknown_fs	HEBV_FS18	1856	latewd_fs
HEBV_FS8	1920	dormant_fs	HEBV_FS18	1881	dormant_fs
HEBV_FS8	2018	bark_year	HEBV_FS18	1892	unknown_fs
HEBV_FS25	1813	pith_year	HEBV_FS18	1899	latewd_fs
HEBV_FS25	1840	unknown_fs	HEBV_FS18	1951	outer_year
HEBV_FS25	1856	unknown_fs	HEBV_FS6	1820	inner_year
HEBV_FS25	1881	dormant_fs	HEBV_FS6	1840	dormant_fs
HEBV_FS25	1892	unknown_fs	HEBV_FS6	1848	latewd_fs
HEBV_FS25	1909	latewd_fs	HEBV_FS6	1881	early_fs
HEBV_FS25	1920	dormant_fs	HEBV_FS6	1892	unknown_fs
HEBV_FS25	2018	bark_year	HEBV_FS6	1896	unknown_fs
HEBV_FS24	1806	pith_year	HEBV_FS6	1899	unknown_fs
HEBV_FS24	1817	unknown_fs	HEBV_FS6	1908	outer_year
HEBV_FS24	1826	unknown_fs	HEBV_FS16	1815	inner_year
HEBV_FS24	1840	unknown_fs	HEBV_FS16	1856	unknown_fs
HEBV_FS24	1856	unknown_fs	HEBV_FS16	1869	latewd_fs
HEBV_FS24	1881	unknown_fs	HEBV_FS16	1892	dormant_fs
HEBV_FS24	1889	outer_year	HEBV_FS16	1910	outer_year
HEBV_FS23	1810	pith_year	HEBV_FS22	1789	inner_year
HEBV_FS23	1840	unknown_fs	HEBV_FS22	1810	unknown_fs
HEBV_FS23	1848	unknown_fs	HEBV_FS22	1817	unknown_fs
HEBV_FS23	1869	unknown_fs	HEBV_FS22	1840	unknown_fs
HEBV_FS23	1881	unknown_fs	HEBV_FS22	1848	unknown_fs
HEBV_FS23	1892	unknown_fs	HEBV_FS22	1873	outer_year
HEBV_FS23	1894	outer_year	HEBV_FS4	1727	inner_year
HEBV_FS26	1782	pith_year	HEBV_FS4	1777	latewd_fs
HEBV_FS26	1817	unknown_fs	HEBV_FS4	1802	unknown_fs
HEBV_FS26	1840	unknown_fs	HEBV_FS4	1810	dormant_fs
HEBV_FS26	1848	unknown_fs	HEBV_FS4	1817	latewd_fs
HEBV_FS26	1869	unknown_fs	HEBV_FS4	1851	outer_year
HEBV_FS26	1881	unknown_fs			
HEBV_FS26	1903	outer_year			

Bayview

sample_ID	year	recorder type
HEBV_FS17	1786	inner_year
HEBV_FS17	1810	unknown_fs
HEBV_FS17	1833	dormant_fs
HEBV_FS17	1840	unknown_fs
HEBV_FS17	1869	unknown_fs
HEBV_FS17	1892	unknown_fs
HEBV_FS17	1910	outer_year
HEBV_FS2	1807	inner_year
HEBV_FS2	1881	unknown_fs
HEBV_FS2	1899	latewd_fs
HEBV_FS2	1910	outer_year
HEBV_FS21	1884	pith_year
HEBV_FS21	1899	latewd_fs
HEBV_FS21	1909	latewd_fs
HEBV_FS21	1923	unknown_fs
HEBV_FS21	1932	unknown_fs
HEBV_FS21	1947	outer_year

Steuben

sample_ID	year	recorder type
STU_FS10	1826	inner_year
STU_FS10	1884	latewd_fs
STU_FS10	1891	early_fs
STU_FS10	1903	middle_fs
STU_FS10	1910	unknown_fs
STU_FS10	1943	outer_year
STU_FS6	1826	inner_year
STU_FS6	1865	unknown_fs
STU_FS6	1884	latewd_fs
STU_FS6	1903	unknown_fs
STU_FS6	1910	unknown_fs
STU_FS6	1929	outer_year
STU_FS7	1865	unknown_fs
STU_FS7	1884	latewd_fs
STU_FS7	1886	unknown_fs
STU_FS7	1903	unknown_fs
STU_FS7	1910	unknown_fs
STU_FS7	1941	outer_year
STU_FS8	1822	inner_year
STU_FS8	1865	dormant_fs
STU_FS8	1884	latewd_fs
STU_FS8	1910	unknown_fs
STU_FS8	1938	outer_year

Big Pine Overlook

sample_ID	year	recorder type	sample_ID	year	recorder type
BPO_FS2	1509	inner_year	BPO_FS8	1546	inner_year
BPO_FS2	1618	latewd_fs	BPO_FS8	1589	unknown_fs
BPO_FS2	1621	unknown_fs	BPO_FS8	1599	unknown_fs
BPO_FS2	1622	unknown_fs	BPO_FS8	1618	latewd_fs
BPO_FS2	1646	unknown_fs	BPO_FS8	1621	late_fs
BPO_FS2	1680	outer_year	BPO_FS8	1623	unknown_fs
BPO_FS3	1542	inner_year	BPO_FS8	1625	latewd_fs
BPO_FS3	1665	dormant_fs	BPO_FS8	1632	late_fs
BPO_FS3	1684	dormant_fs	BPO_FS8	1636	early_fs
BPO_FS3	1694	unknown_fs	BPO_FS8	1639	late_fs
BPO_FS3	1742	outer_year	BPO_FS8	1641	unknown_fs
BPO_FS4	1501	inner_year	BPO_FS8	1644	latewd_fs
BPO_FS4	1702	unknown_fs	BPO_FS8	1645	dormant_fs
BPO_FS4	1710	latewd_fs	BPO_FS8	1646	latewd_fs
BPO_FS4	1740	outer_year	BPO_FS8	1651	latewd_fs
BPO_FS5	1605	inner_year	BPO_FS8	1725	outer_year
BPO_FS5	1646	latewd_fs	BPO_FS9	1553	inner_year
BPO_FS5	1659	latewd_fs	BPO_FS9	1618	latewd_fs
BPO_FS5	1716	unknown_fs	BPO_FS9	1636	late_fs
BPO_FS5	1780	outer_year	BPO_FS9	1665	unknown_fs
BPO_FS6	1590	inner_year	BPO_FS9	1668	late_fs
BPO_FS6	1615	early_fs	BPO_FS9	1682	latewd_fs
BPO_FS6	1616	unknown_fs	BPO_FS9	1711	outer_year
BPO_FS6	1618	unknown_fs	BPO_FS9	1668	late_fs
BPO_FS6	1646	latewd_fs	BPO_FS9	1682	latewd_fs
BPO_FS6	1677	latewd_fs	BPO_FS9	1711	outer_year
BPO_FS6	1738	outer_year			
BPO_FS7	1549	inner_year			
BPO_FS7	1647	unknown_fs			
BPO_FS7	1665	unknown_fs			
BPO_FS7	1668	unknown_fs			
BPO_FS7	1677	middle_fs			
BPO_FS7	1719	latewd_fs			
BPO_FS7	1743	unknown_fs			
BPO_FS7	1744	outer_year			

Corner Lake

sample_ID	year	recorder type	sample_ID	year	recorder type
HCL_FS1	1722	inner_year	HCL_FS20	1726	inner_year
HCL_FS1	1754	dormant_fs	HCL_FS20	1754	unknown_fs
HCL_FS1	1773	unknown_fs	HCL_FS20	1773	unknown_fs
HCL_FS1	1844	outer_year	HCL_FS20	1779	latewd_fs
HCL_FS9	1861	inner_year	HCL_FS20	1788	latewd_fs
HCL_FS9	1899	latewd_fs	HCL_FS20	1791	latewd_fs
HCL_FS9	1904	unknown_fs	HCL_FS20	1842	outer_year
HCL_FS9	1910	unknown_fs	HCL_FS2	1715	inner_year
HCL_FS9	1918	late_fs	HCL_FS2	1754	early_fs
HCL_FS9	2017	bark_year	HCL_FS2	1768	unknown_fs
HCL_FS8	1721	inner_year	HCL_FS2	1791	latewd_fs
HCL_FS8	1754	middle_fs	HCL_FS2	1833	outer_year
HCL_FS8	1773	dormant_fs	HCL_FS19	1729	inner_year
HCL_FS8	1792	dormant_fs	HCL_FS19	1773	dormant_fs
HCL_FS8	1833	outer_year	HCL_FS19	1791	latewd_fs
HCL_FS7	1740	inner_year	HCL_FS19	1834	outer_year
HCL_FS7	1773	early_fs	HCL_FS18	1736	inner_year
HCL_FS7	1807	unknown_fs	HCL_FS18	1754	early_fs
HCL_FS7	1839	outer_year	HCL_FS18	1773	dormant_fs
HCL_FS6	1881	inner_year	HCL_FS18	1789	outer_year
HCL_FS6	1918	unknown_fs	HCL_FS17	1810	inner_year
HCL_FS6	1938	unknown_fs	HCL_FS17	1896	latewd_fs
HCL_FS6	2017	bark_year	HCL_FS17	1905	unknown_fs
HCL_FS5	1709	inner_year	HCL_FS17	1910	unknown_fs
HCL_FS5	1754	unknown_fs	HCL_FS17	1946	unknown_fs
HCL_FS5	1773	unknown_fs	HCL_FS17	2017	bark_year
HCL_FS5	1812	unknown_fs	HCL_FS16	1719	inner_year
HCL_FS5	1817	outer_year	HCL_FS16	1754	unknown_fs
HCL_FS4	1706	pith_year	HCL_FS16	1773	dormant_fs
HCL_FS4	1736	latewd_fs	HCL_FS16	1791	latewd_fs
HCL_FS4	1754	unknown_fs	HCL_FS16	1835	outer_year
HCL_FS4	1778	dormant_fs	HCL_FS15	1706	pith_year
HCL_FS4	1782	unknown_fs	HCL_FS15	1754	dormant_fs
HCL_FS4	1792	dormant_fs	HCL_FS15	1773	dormant_fs
HCL_FS4	1797	unknown_fs	HCL_FS15	1792	unknown_fs
HCL_FS4	1803	outer_year	HCL_FS15	1854	outer_year
HCL_FS3	1725	inner_year	HCL_FS13	1830	inner_year
HCL_FS3	1754	early_fs	HCL_FS13	1896	dormant_fs
HCL_FS3	1773	dormant_fs	HCL_FS13	1905	dormant_fs
HCL_FS3	1792	unknown_fs	HCL_FS13	1910	latewd_fs
HCL_FS3	1833	outer_year	HCL_FS13	1989	outer_year

Corner Lake

sample_ID	year	recorder type	sample_ID	year	recorder type
HCL_FS1	1722	inner_year	HCL_FS20	1726	inner_year
HCL_FS1	1754	dormant_fs	HCL_FS20	1754	unknown_fs
HCL_FS1	1773	unknown_fs	HCL_FS20	1773	unknown_fs
HCL_FS1	1844	outer_year	HCL_FS20	1779	latewd_fs
HCL_FS9	1861	inner_year	HCL_FS20	1788	latewd_fs
HCL_FS9	1899	latewd_fs	HCL_FS20	1791	latewd_fs
HCL_FS9	1904	unknown_fs	HCL_FS20	1842	outer_year
HCL_FS9	1910	unknown_fs	HCL_FS2	1715	inner_year
HCL_FS9	1918	late_fs	HCL_FS2	1754	early_fs
HCL_FS9	2017	bark_year	HCL_FS2	1768	unknown_fs
HCL_FS8	1721	inner_year	HCL_FS2	1791	latewd_fs
HCL_FS8	1754	middle_fs	HCL_FS2	1833	outer_year
HCL_FS8	1773	dormant_fs	HCL_FS19	1729	inner_year
HCL_FS8	1792	dormant_fs	HCL_FS19	1773	dormant_fs
HCL_FS8	1833	outer_year	HCL_FS19	1791	latewd_fs
HCL_FS7	1740	inner_year	HCL_FS19	1834	outer_year
HCL_FS7	1773	early_fs	HCL_FS18	1736	inner_year
HCL_FS7	1807	unknown_fs	HCL_FS18	1754	early_fs
HCL_FS7	1839	outer_year	HCL_FS18	1773	dormant_fs
HCL_FS6	1881	inner_year	HCL_FS18	1789	outer_year
HCL_FS6	1918	unknown_fs	HCL_FS17	1810	inner_year
HCL_FS6	1938	unknown_fs	HCL_FS17	1896	latewd_fs
HCL_FS6	2017	bark_year	HCL_FS17	1905	unknown_fs
HCL_FS5	1709	inner_year	HCL_FS17	1910	unknown_fs
HCL_FS5	1754	unknown_fs	HCL_FS17	1946	unknown_fs
HCL_FS5	1773	unknown_fs	HCL_FS17	2017	bark_year
HCL_FS5	1812	unknown_fs	HCL_FS16	1719	inner_year
HCL_FS5	1817	outer_year	HCL_FS16	1754	unknown_fs
HCL_FS4	1706	pith_year	HCL_FS16	1773	dormant_fs
HCL_FS4	1736	latewd_fs	HCL_FS16	1791	latewd_fs
HCL_FS4	1754	unknown_fs	HCL_FS16	1835	outer_year
HCL_FS4	1778	dormant_fs	HCL_FS15	1706	pith_year
HCL_FS4	1782	unknown_fs	HCL_FS15	1754	dormant_fs
HCL_FS4	1792	dormant_fs	HCL_FS15	1773	dormant_fs
HCL_FS4	1797	unknown_fs	HCL_FS15	1792	unknown_fs
HCL_FS4	1803	outer_year	HCL_FS15	1854	outer_year
HCL_FS3	1725	inner_year	HCL_FS13	1830	inner_year
HCL_FS3	1754	early_fs	HCL_FS13	1896	dormant_fs
HCL_FS3	1773	dormant_fs	HCL_FS13	1905	dormant_fs
HCL_FS3	1792	unknown_fs	HCL_FS13	1910	latewd_fs
HCL_FS3	1833	outer_year	HCL_FS13	1989	outer_year

Corner Lake

sample_ID	year	recorder type	sample_ID	year	recorder type
HCL_FS12	1734	inner_year	HCL_FS10	1708	pith_year
HCL_FS12	1754	unknown_fs	HCL_FS10	1754	early_fs
HCL_FS12	1773	dormant_fs	HCL_FS10	1773	dormant_fs
HCL_FS12	1791	latewd_fs	HCL_FS10	1791	latewd_fs
HCL_FS12	1833	outer_year	HCL_FS10	1827	outer_year
HCL_FS11	1630	inner_year			
HCL_FS11	1699	latewd_fs			
HCL_FS11	1700	latewd_fs			
HCL_FS11	1818	outer_year			

Off Road Valley

sample_ID	year	recorder type	sample_ID	year	recorder type
ORV_FS2	1715	inner_year	ORV_FS13	1732	inner_year
ORV_FS2	1754	latewd_fs	ORV_FS13	1754	latewd_fs
ORV_FS2	1809	latewd_fs	ORV_FS13	1791	latewd_fs
ORV_FS2	1813	unknown_fs	ORV_FS13	1837	outer_year
ORV_FS2	1825	unknown_fs	ORV_FS14	1733	inner_year
ORV_FS2	1827	outer_year	ORV_FS14	1754	latewd_fs
ORV_FS3	1724	inner_year	ORV_FS14	1758	latewd_fs
ORV_FS3	1754	latewd_fs	ORV_FS14	1791	latewd_fs
ORV_FS3	1778	latewd_fs	ORV_FS14	1804	outer_year
ORV_FS3	1791	latewd_fs	ORV_FS15	1713	pith_year
ORV_FS3	1799	early_fs	ORV_FS15	1754	latewd_fs
ORV_FS3	1809	latewd_fs	ORV_FS15	1791	late_fs
ORV_FS3	1846	latewd_fs	ORV_FS15	1809	latewd_fs
ORV_FS3	1861	outer_year	ORV_FS15	1840	outer_year
ORV_FS4	1732	inner_year	ORV_FS16	1719	inner_year
ORV_FS4	1791	latewd_fs	ORV_FS16	1755	unknown_fs
ORV_FS4	1793	latewd_fs	ORV_FS16	1768	latewd_fs
ORV_FS4	1809	latewd_fs	ORV_FS16	1794	late_fs
ORV_FS4	1813	dormant_fs	ORV_FS16	1800	dormant_fs
ORV_FS4	1822	latewd_fs	ORV_FS16	1809	latewd_fs
ORV_FS4	1830	dormant_fs	ORV_FS16	1850	outer_year
ORV_FS4	1838	outer_year	ORV_FS18	1746	inner_year
			ORV_FS18	1754	latewd_fs
			ORV_FS18	1763	unknown_fs
			ORV_FS18	1782	unknown_fs
			ORV_FS18	1817	outer_year

Highway 13 Plantation

sample_ID	year	recorder type	sample_ID	year	recorder type
HP_FS9	1838	inner_year	HP_FS2	1672	inner_year
HP_FS9	1910	unknown_fs	HP_FS2	1678	unknown_fs
HP_FS9	1961	unknown_fs	HP_FS2	1692	latewd_fs
HP_FS9	2017	bark_year	HP_FS2	1694	latewd_fs
HP_FS10	1784	pith_year	HP_FS2	1700	dormant_fs
HP_FS10	1892	unknown_fs	HP_FS2	1711	dormant_fs
HP_FS10	1910	unknown_fs	HP_FS2	1713	latewd_fs
HP_FS10	2017	bark_year	HP_FS2	1737	unknown_fs
HP_FS13	1586	inner_year	HP_FS2	1754	latewd_fs
HP_FS13	1663	unknown_fs	HP_FS2	1761	unknown_fs
HP_FS13	1700	dormant_fs	HP_FS2	1782	outer_year
HP_FS13	1711	dormant_fs	HP_FS20	1648	inner_year
HP_FS13	1754	late_fs	HP_FS20	1694	unknown_fs
HP_FS13	1768	latewd_fs	HP_FS20	1700	unknown_fs
HP_FS13	1850	outer_year	HP_FS20	1711	unknown_fs
HP_FS14	1582	inner_year	HP_FS20	1754	latewd_fs
HP_FS14	1630	dormant_fs	HP_FS20	1778	outer_year
HP_FS14	1662	dormant_fs	HP_FS21	1671	inner_year
HP_FS14	1667	dormant_fs	HP_FS21	1700	unknown_fs
HP_FS14	1700	dormant_fs	HP_FS21	1717	dormant_fs
HP_FS14	1714	unknown_fs	HP_FS21	1718	dormant_fs
HP_FS14	1761	outer_year	HP_FS21	1754	latewd_fs
HP_FS16	1728	pith_year	HP_FS21	1887	outer_year
HP_FS16	1755	dormant_fs	HP_FS22	1583	inner_year
HP_FS16	1813	outer_year	HP_FS22	1686	dormant_fs
HP_FS17	1625	inner_year	HP_FS22	1711	early_fs
HP_FS17	1664	unknown_fs	HP_FS22	1719	unknown_fs
HP_FS17	1691	middle_fs	HP_FS22	1738	unknown_fs
HP_FS17	1699	latewd_fs	HP_FS22	1754	latewd_fs
HP_FS17	1745	unknown_fs	HP_FS22	1843	unknown_fs
HP_FS17	1799	outer_year	HP_FS22	1871	outer_year
HP_FS18	1596	inner_year	HP_FS23	1577	inner_year
HP_FS18	1711	unknown_fs	HP_FS23	1700	dormant_fs
HP_FS18	1720	unknown_fs	HP_FS23	1701	unknown_fs
HP_FS18	1738	unknown_fs	HP_FS23	1702	unknown_fs
HP_FS18	1754	latewd_fs	HP_FS23	1704	late_fs
HP_FS18	1831	latewd_fs	HP_FS23	1706	latewd_fs
HP_FS18	1838	unknown_fs	HP_FS23	1711	dormant_fs
HP_FS18	1846	unknown_fs	HP_FS23	1713	latewd_fs
HP_FS18	1857	unknown_fs	HP_FS23	1771	outer_year
HP_FS18	1862	outer_year			

Highway 13 Plantation

sample_ID	year	recorder type	sample_ID	year	recorder type
HP_FS19	1574	inner_year	HP_FS4	1636	inner_year
HP_FS19	1689	latewd_fs	HP_FS4	1711	early_fs
HP_FS19	1700	dormant_fs	HP_FS4	1754	latewd_fs
HP_FS19	1711	dormant_fs	HP_FS4	1761	unknown_fs
HP_FS19	1829	outer_year	HP_FS4	1790	outer_year
HP_FS5	1858	outer_year	HP_FS5	1596	inner_year
HP_FS7	1692	inner_year	HP_FS5	1638	dormant_fs
HP_FS7	1699	latewd_fs	HP_FS5	1700	unknown_fs
HP_FS7	1711	dormant_fs	HP_FS5	1711	unknown_fs
HP_FS7	1769	dormant_fs			
HP_FS7	1858	outer_year			
HP_FS8	1542	inner_year			
HP_FS8	1574	unknown_fs			
HP_FS8	1617	middle_fs			
HP_FS8	1700	dormant_fs			
HP_FS8	1705	unknown_fs			
HP_FS8	1706	unknown_fs			
HP_FS8	1754	late_fs			
HP_FS8	1807	outer_year			

Eagle Lake

sample_ID	year	recorder type
EL_FS1	1818	pith_year
EL_FS1	1910	early_fs
EL_FS1	1924	unknown_fs
EL_FS1	1933	unknown_fs
EL_FS1	1994	unknown_fs
EL_FS1	2017	bark_year

Peck Lake

sample_ID	year	recorder type
PL_FS1	1518	inner_year
PL_FS1	1616	unknown_fs
PL_FS1	1645	unknown_fs
PL_FS1	1689	unknown_fs
PL_FS1	1700	unknown_fs
PL_FS1	1716	outer_year
PL_FS2	1574	inner_year
PL_FS2	1656	unknown_fs
PL_FS2	1724	outer_year
PL_FS20	1634	inner_year
PL_FS20	1654	unknown_fs
PL_FS20	1703	dormant_fs
PL_FS20	1810	outer_year
PL_FS22	1531	inner_year
PL_FS22	1600	unknown_fs
PL_FS22	1690	unknown_fs
PL_FS22	1699	latewd_fs
PL_FS22	1733	unknown_fs
PL_FS22	1735	unknown_fs
PL_FS22	1739	unknown_fs
PL_FS22	1741	unknown_fs
PL_FS22	1780	outer_year
PL_FS3	1681	inner_year
PL_FS3	1708	unknown_fs
PL_FS3	1723	unknown_fs
PL_FS3	1739	unknown_fs
PL_FS3	1748	unknown_fs
PL_FS3	1791	unknown_fs
PL_FS3	1814	outer_year
PL_FS5	1648	inner_year
PL_FS5	1664	unknown_fs
PL_FS5	1700	dormant_fs
PL_FS5	1715	unknown_fs
PL_FS5	1723	unknown_fs
PL_FS5	1797	outer_year

sample_ID	year	recorder type
PL_FS6	1607	inner_year
PL_FS6	1619	unknown_fs
PL_FS6	1664	unknown_fs
PL_FS6	1668	unknown_fs
PL_FS6	1752	unknown_fs
PL_FS6	1763	unknown_fs
PL_FS6	1774	unknown_fs
PL_FS6	1782	dormant_fs
PL_FS6	1794	unknown_fs
PL_FS6	1818	unknown_fs
PL_FS6	1822	unknown_fs
PL_FS6	1831	outer_year

Pine Bluff Trail

sample_ID	year	recorder type	sample_ID	year	recorder type
PBT_FS6	1776	pith_year	PBT_FS1	1801	inner_year
PBT_FS6	1862	unknown_fs	PBT_FS1	1862	late_fs
PBT_FS6	1891	dormant_fs	PBT_FS1	1870	dormant_fs
PBT_FS6	1923	unknown_fs	PBT_FS1	1884	late_fs
PBT_FS6	1927	unknown_fs	PBT_FS1	1891	dormant_fs
PBT_FS6	2007	bark_year	PBT_FS1	1908	late_fs
PBT_FS12	1778	pith_year	PBT_FS1	1914	dormant_fs
PBT_FS12	1862	unknown_fs	PBT_FS1	1919	dormant_fs
PBT_FS12	1884	late_fs	PBT_FS1	1965	outer_year
PBT_FS12	1891	dormant_fs	PBT_FS9	1662	unknown_fs
PBT_FS12	1918	outer_year	PBT_FS9	1682	middle_fs
PBT_FS8	1781	inner_year	PBT_FS9	1685	late_fs
PBT_FS8	1796	dormant_fs	PBT_FS9	1752	dormant_fs
PBT_FS8	1862	unknown_fs	PBT_FS9	1870	outer_year
PBT_FS8	1884	late_fs	PBT_FS5	1650	inner_year
PBT_FS8	1891	dormant_fs	PBT_FS5	1752	dormant_fs
PBT_FS8	1919	unknown_fs	PBT_FS5	1798	unknown_fs
PBT_FS8	1923	outer_year	PBT_FS5	1850	outer_year
PBT_FS4	1800	inner_year	PBT_FS3	1574	pith_year
PBT_FS4	1862	middle_fs	PBT_FS3	1659	dormant_fs
PBT_FS4	1884	middle_fs	PBT_FS3	1670	unknown_fs
PBT_FS4	1891	unknown_fs	PBT_FS3	1682	early_fs
PBT_FS4	1922	outer_year	PBT_FS3	1693	dormant_fs
PBT_FS7	1783	inner_year	PBT_FS3	1697	unknown_fs
PBT_FS7	1908	unknown_fs	PBT_FS3	1731	unknown_fs
PBT_FS7	1914	dormant_fs	PBT_FS3	1792	outer_year
PBT_FS7	1919	dormant_fs			
PBT_FS7	1925	outer_year			
PBT_FS10	1780	pith_year			
PBT_FS10	1862	unknown_fs			
PBT_FS10	1891	dormant_fs			
PBT_FS10	1923	dormant_fs			
PBT_FS10	2020	bark_year			
PBT_FS2	1800	inner_year			
PBT_FS2	1862	late_fs			
PBT_FS2	1884	unknown_fs			
PBT_FS2	1890	outer_year			

Bears Den Overlook

sample_ID	year	recorder type
BDO_FS3	1761	pith_year
BDO_FS3	1798	dormant_fs
BDO_FS3	1825	unknown_fs
BDO_FS3	1878	outer_year
BDO_FS4	1767	pith_year
BDO_FS4	1824	unknown_fs
BDO_FS4	1828	unknown_fs
BDO_FS4	1884	unknown_fs
BDO_FS4	1895	early_fs
BDO_FS4	1932	outer_year
BDO_FS7	1763	pith_year
BDO_FS7	1825	dormant_fs
BDO_FS7	1875	outer_year
BDO_FS2	1753	inner_year
BDO_FS2	1824	late_fs
BDO_FS2	1884	unknown_fs
BDO_FS2	1909	dormant_fs
BDO_FS2	1919	outer_year
BDO_FS16	1776	inner_year
BDO_FS16	1824	late_fs
BDO_FS16	1829	dormant_fs
BDO_FS16	1884	dormant_fs
BDO_FS16	1891	dormant_fs
BDO_FS16	1895	dormant_fs
BDO_FS16	1909	dormant_fs
BDO_FS16	1922	outer_year
BDO_FS5	1770	pith_year
BDO_FS5	1824	late_fs
BDO_FS5	1828	dormant_fs
BDO_FS5	1884	dormant_fs
BDO_FS5	1891	dormant_fs
BDO_FS5	1895	dormant_fs
BDO_FS5	1936	outer_year
BDO_FS1	1746	inner_year
BDO_FS1	1824	late_fs
BDO_FS1	1828	dormant_fs
BDO_FS1	1891	unknown_fs
BDO_FS1	1908	outer_year

sample_ID	year	recorder type
BDO_FS17	1811	inner_year
BDO_FS17	1891	dormant_fs
BDO_FS17	1895	dormant_fs
BDO_FS17	1908	outer_year
BDO_FS15	1750	inner_year
BDO_FS15	1824	unknown_fs
BDO_FS15	1884	dormant_fs
BDO_FS15	1909	dormant_fs
BDO_FS15	1934	bark_year
BDO_FS18	1650	inner_year
BDO_FS18	1721	dormant_fs
BDO_FS18	1752	dormant_fs
BDO_FS18	1777	outer_year
BDO_FS19	1674	inner_year
BDO_FS19	1721	dormant_fs
BDO_FS19	1752	dormant_fs
BDO_FS19	1759	dormant_fs
BDO_FS19	1807	outer_year
BDO_FS20	1771	inner_year
BDO_FS20	1782	unknown_fs
BDO_FS20	1824	unknown_fs
BDO_FS20	1891	unknown_fs
BDO_FS20	1906	dormant_fs
BDO_FS20	1920	outer_year
BDO_FS6	1785	inner_year
BDO_FS6	1825	unknown_fs
BDO_FS6	1895	unknown_fs
BDO_FS6	2020	bark_year

Fern Onion Lake

sample_ID	year	recorder type
FO_FS1	1620	pith_year
FO_FS1	1646	late_fs
FO_FS1	1647	dormant_fs
FO_FS1	1681	late_fs
FO_FS1	1717	unknown_fs
FO_FS1	1753	outer_year
FO_FS10	1655	unknown_fs
FO_FS10	1681	unknown_fs
FO_FS10	1717	late_fs
FO_FS10	1791	outer_year
FO_FS2	1648	unknown_fs
FO_FS2	1697	unknown_fs
FO_FS2	1717	late_fs
FO_FS2	1738	unknown_fs
FO_FS2	1754	unknown_fs
FO_FS2	1757	unknown_fs
FO_FS2	1774	outer_year
FO_FS3	1621	pith_year
FO_FS3	1646	latewd_fs
FO_FS3	1681	unknown_fs
FO_FS3	1717	late_fs
FO_FS3	1791	outer_year
FO_FS4	1617	pith_year
FO_FS4	1646	latewd_fs
FO_FS4	1664	dormant_fs
FO_FS4	1681	late_fs
FO_FS4	1717	unknown_fs
FO_FS4	1755	dormant_fs
FO_FS4	1797	outer_year
FO_FS5	1621	pith_year
FO_FS5	1681	late_fs
FO_FS5	1717	late_fs
FO_FS5	1733	latewd_fs
FO_FS5	1754	latewd_fs
FO_FS5	1818	unknown_fs
FO_FS5	1829	outer_year

sample_ID	year	recorder type
FO_FS6	1632	inner_year
FO_FS6	1646	late_fs
FO_FS6	1661	unknown_fs
FO_FS6	1665	latewd_fs
FO_FS6	1685	unknown_fs
FO_FS6	1697	unknown_fs
FO_FS6	1699	latewd_fs
FO_FS6	1717	late_fs
FO_FS6	1738	dormant_fs
FO_FS6	1743	dormant_fs
FO_FS6	1766	unknown_fs
FO_FS7	1620	pith_year
FO_FS7	1667	unknown_fs
FO_FS7	1717	unknown_fs
FO_FS7	1720	dormant_fs
FO_FS7	1788	outer_year
FO_FS8	1654	inner_year
FO_FS8	1717	unknown_fs
FO_FS8	1783	outer_year

Ramsey Lake

sample_ID	year	recorder type	sample_ID	year	recorder type
RALA_FS68	1901	pith_year	RALA_FS58	1747	pith_year
RALA_FS68	1932	unknown_fs	RALA_FS58	1837	dormant_fs
RALA_FS68	1991	outer_year	RALA_FS58	1902	outer_year
RALA_FS56	1872	inner_year	RALA_FS11	1741	inner_year
RALA_FS56	1891	latewd_fs	RALA_FS11	1754	unknown_fs
RALA_FS56	1910	latewd_fs	RALA_FS11	1774	latewd_fs
RALA_FS56	1932	dormant_fs	RALA_FS11	1827	early_fs
RALA_FS56	2019	bark_year	RALA_FS11	1846	outer_year
RALA_FS61	1864	pith_year	RALA_FS28	1737	inner_year
RALA_FS61	1891	latewd_fs	RALA_FS28	1751	latewd_fs
RALA_FS61	1900	dormant_fs	RALA_FS28	1774	latewd_fs
RALA_FS61	1932	dormant_fs	RALA_FS28	1787	dormant_fs
RALA_FS61	2019	bark_year	RALA_FS28	1796	unknown_fs
RALA_FS49	1847	unknown_fs	RALA_FS28	1800	outer_year
RALA_FS49	1891	latewd_fs	RALA_FS6	1731	pith_year
RALA_FS49	1910	latewd_fs	RALA_FS6	1827	dormant_fs
RALA_FS49	1932	unknown_fs	RALA_FS6	1867	latewd_fs
RALA_FS49	1997	outer_year	RALA_FS6	1910	middle_fs
RALA_FS16	1799	pith_year	RALA_FS6	1920	unknown_fs
RALA_FS16	1856	unknown_fs	RALA_FS6	1943	outer_year
RALA_FS16	1891	latewd_fs	RALA_FS69	1725	inner_year
RALA_FS16	1920	dormant_fs	RALA_FS69	1733	latewd_fs
RALA_FS16	1966	bark_year	RALA_FS69	1840	outer_year
RALA_FS72	1797	pith_year	RALA_FS33	1716	inner_year
RALA_FS72	1932	dormant_fs	RALA_FS33	1733	unknown_fs
RALA_FS72	1986	outer_year	RALA_FS33	1751	unknown_fs
RALA_FS53	1796	pith_year	RALA_FS33	1774	unknown_fs
RALA_FS53	1910	latewd_fs	RALA_FS33	1803	unknown_fs
RALA_FS53	1932	unknown_fs	RALA_FS33	1847	unknown_fs
RALA_FS53	2019	bark_year	RALA_FS33	1882	unknown_fs
RALA_FS63	1787	pith_year	RALA_FS33	1889	outer_year
RALA_FS63	1847	unknown_fs	RALA_FS2	1709	inner_year
RALA_FS63	1890	outer_year	RALA_FS2	1751	unknown_fs
RALA_FS27	1774	inner_year	RALA_FS2	1867	outer_year
RALA_FS27	1866	middle_fs			
RALA_FS27	1903	outer_year			

Ramsey Lake

sample_ID	year	recorder type	sample_ID	year	recorder type
RALA_FS10	1755	inner_year	RALA_FS22	1694	inner_year
RALA_FS10	1774	unknown_fs	RALA_FS22	1715	latewd_fs
RALA_FS10	1811	unknown_fs	RALA_FS22	1718	latewd_fs
RALA_FS10	1847	unknown_fs	RALA_FS22	1724	latewd_fs
RALA_FS10	1891	unknown_fs	RALA_FS22	1737	dormant_fs
RALA_FS10	1910	outer_year	RALA_FS22	1852	outer_year
RALA_FS45	1694	inner_year	RALA_FS65	1687	inner_year
RALA_FS45	1737	dormant_fs	RALA_FS65	1699	latewd_fs
RALA_FS45	1744	latewd_fs	RALA_FS65	1720	unknown_fs
RALA_FS45	1754	latewd_fs	RALA_FS65	1748	unknown_fs
RALA_FS45	1774	latewd_fs	RALA_FS65	1751	unknown_fs
RALA_FS45	1791	latewd_fs	RALA_FS65	1835	outer_year
RALA_FS45	1842	outer_year	RALA_FS39	1682	inner_year
RALA_FS23	1662	inner_year	RALA_FS39	1718	unknown_fs
RALA_FS23	1718	unknown_fs	RALA_FS39	1744	unknown_fs
RALA_FS23	1733	unknown_fs	RALA_FS39	1759	outer_year
RALA_FS23	1751	unknown_fs	RALA_FS21	1681	inner_year
RALA_FS23	1774	unknown_fs	RALA_FS21	1754	unknown_fs
RALA_FS23	1803	unknown_fs	RALA_FS21	1774	unknown_fs
RALA_FS23	1829	outer_year	RALA_FS21	1787	unknown_fs
RALA_FS46	1655	pith_year	RALA_FS21	1920	outer_year
RALA_FS46	1744	latewd_fs	RALA_FS34	1680	inner_year
RALA_FS46	1754	latewd_fs	RALA_FS34	1733	latewd_fs
RALA_FS46	1783	outer_year	RALA_FS34	1751	unknown_fs
RALA_FS32	1654	inner_year	RALA_FS34	1774	unknown_fs
RALA_FS32	1751	unknown_fs	RALA_FS34	1832	outer_year
RALA_FS32	1774	latewd_fs	RALA_FS1	1680	inner_year
RALA_FS32	1803	unknown_fs	RALA_FS1	1718	unknown_fs
RALA_FS32	1842	outer_year	RALA_FS1	1754	latewd_fs
RALA_FS55	1654	inner_year	RALA_FS1	1774	latewd_fs
RALA_FS55	1748	unknown_fs	RALA_FS1	1800	latewd_fs
RALA_FS55	1754	unknown_fs	RALA_FS1	1847	unknown_fs
RALA_FS55	1774	dormant_fs	RALA_FS1	1867	outer_year
RALA_FS55	1847	dormant_fs	RALA_FS66	1677	inner_year
RALA_FS55	1893	outer_year	RALA_FS66	1703	unknown_fs
			RALA_FS66	1709	dormant_fs
			RALA_FS66	1718	dormant_fs
			RALA_FS66	1754	latewd_fs
			RALA_FS66	1774	latewd_fs
			RALA_FS66	1829	outer_year

Ramsey Lake

sample_ID		year	recorder type	sample_ID	year	recorder type
RALA_FS5	1651	inner_year	RALA_FS12	1652	inner_year	
RALA_FS5	1718	unknown_fs	RALA_FS12	1718	dormant_fs	
RALA_FS5	1744	unknown_fs	RALA_FS12	1744	latewd_fs	
RALA_FS5	1754	latewd_fs	RALA_FS12	1754	latewd_fs	
RALA_FS5	1774	latewd_fs	RALA_FS12	1774	latewd_fs	
RALA_FS5	1811	unknown_fs	RALA_FS12	1817	unknown_fs	
RALA_FS5	1840	outer_year	RALA_FS12	1827	early_fs	
RALA_FS78	1650	inner_year	RALA_FS12	1837	unknown_fs	
RALA_FS78	1744	latewd_fs	RALA_FS12	1872	outer_year	
RALA_FS78	1754	latewd_fs	RALA_FS26	1625	inner_year	
RALA_FS78	1765	outer_year	RALA_FS26	1691	unknown_fs	
RALA_FS50	1641	inner_year	RALA_FS26	1718	unknown_fs	
RALA_FS50	1718	unknown_fs	RALA_FS26	1733	unknown_fs	
RALA_FS50	1744	latewd_fs	RALA_FS26	1751	unknown_fs	
RALA_FS50	1754	latewd_fs	RALA_FS26	1801	outer_year	
RALA_FS50	1774	latewd_fs	RALA_FS3	1619	pith_year	
RALA_FS50	1836	outer_year	RALA_FS3	1671	unknown_fs	
RALA_FS31	1637	inner_year	RALA_FS3	1687	dormant_fs	
RALA_FS31	1733	latewd_fs	RALA_FS3	1698	unknown_fs	
RALA_FS31	1751	middle_fs	RALA_FS3	1733	latewd_fs	
RALA_FS31	1774	latewd_fs	RALA_FS3	1754	latewd_fs	
RALA_FS31	1803	latewd_fs	RALA_FS3	1799	unknown_fs	
RALA_FS31	1847	unknown_fs	RALA_FS3	1803	outer_year	
RALA_FS31	1867	outer_year	RALA_FS36	1614	pith_year	
RALA_FS25	1635	pith_year	RALA_FS36	1689	middle_fs	
RALA_FS25	1718	latewd_fs	RALA_FS36	1718	unknown_fs	
RALA_FS25	1733	latewd_fs	RALA_FS36	1733	unknown_fs	
RALA_FS25	1756	outer_year	RALA_FS36	1751	unknown_fs	
RALA_FS14	1630	inner_year	RALA_FS36	1754	unknown_fs	
RALA_FS14	1744	latewd_fs	RALA_FS36	1786	outer_year	
RALA_FS14	1798	outer_year	RALA_FS9	1570	inner_year	
RALA_FS73	1628	pith_year	RALA_FS9	1637	latewd_fs	
RALA_FS73	1718	dormant_fs	RALA_FS9	1709	unknown_fs	
RALA_FS73	1744	latewd_fs	RALA_FS9	1785	outer_year	
RALA_FS73	1820	outer_year				

Haymeadow Flowage

sample_ID	year	recorder type
HAFL_FS11	1697	inner_year
HAFL_FS11	1785	dormant_fs
HAFL_FS11	1793	unknown_fs
HAFL_FS11	1851	unknown_fs
HAFL_FS11	1856	outer_year
HAFL_FS4	1741	inner_year
HAFL_FS4	1845	unknown_fs
HAFL_FS4	1851	unknown_fs
HAFL_FS4	1855	unknown_fs
HAFL_FS4	1868	outer_year
HAFL_FS35	1762	pith_year
HAFL_FS35	1801	dormant_fs
HAFL_FS35	1825	unknown_fs
HAFL_FS35	1845	dormant_fs
HAFL_FS35	1860	dormant_fs
HAFL_FS35	1863	dormant_fs
HAFL_FS35	1866	dormant_fs
HAFL_FS35	1868	dormant_fs
HAFL_FS35	1876	outer_year
HAFL_FS37	1769	inner_year
HAFL_FS37	1801	unknown_fs
HAFL_FS37	1845	dormant_fs
HAFL_FS37	1860	dormant_fs
HAFL_FS37	1890	outer_year
HAFL_FS43	1770	inner_year
HAFL_FS43	1851	dormant_fs
HAFL_FS43	1878	outer_year
HAFL_FS34	1776	inner_year
HAFL_FS34	1801	dormant_fs
HAFL_FS34	1845	dormant_fs
HAFL_FS34	1860	unknown_fs
HAFL_FS34	1868	dormant_fs
HAFL_FS34	1883	outer_year
HAFL_FS18	1779	pith_year
HAFL_FS18	1891	unknown_fs
HAFL_FS18	2019	bark_year

sample_ID	year	recorder type
HAFL_FS22	1780	inner_year
HAFL_FS22	1842	dormant_fs
HAFL_FS22	1845	unknown_fs
HAFL_FS22	1847	unknown_fs
HAFL_FS22	1855	unknown_fs
HAFL_FS22	1860	dormant_fs
HAFL_FS22	1863	dormant_fs
HAFL_FS22	1866	unknown_fs
HAFL_FS22	1868	unknown_fs
HAFL_FS22	1874	unknown_fs
HAFL_FS22	1880	unknown_fs
HAFL_FS22	1891	unknown_fs
HAFL_FS22	2019	bark_year
HAFL_FS1	1786	inner_year
HAFL_FS1	1891	dormant_fs
HAFL_FS1	2019	bark_year
HAFL_FS36	1791	pith_year
HAFL_FS36	1829	unknown_fs
HAFL_FS36	1891	dormant_fs
HAFL_FS36	1904	outer_year
HAFL_FS45	1800	inner_year
HAFL_FS45	1851	unknown_fs
HAFL_FS45	1873	outer_year
HAFL_FS31	1803	inner_year
HAFL_FS31	1825	unknown_fs
HAFL_FS31	1829	unknown_fs
HAFL_FS31	1860	unknown_fs
HAFL_FS31	1868	dormant_fs
HAFL_FS31	1883	dormant_fs
HAFL_FS31	1891	dormant_fs
HAFL_FS31	1913	outer_year
HAFL_FS38	1805	inner_year
HAFL_FS38	1891	unknown_fs
HAFL_FS38	1909	outer_year
HAFL_FS33	1809	pith_year
HAFL_FS33	1845	dormant_fs
HAFL_FS33	1847	dormant_fs
HAFL_FS33	1860	dormant_fs
HAFL_FS33	1868	unknown_fs
HAFL_FS33	1890	outer_year

Haymeadow Flowage

sample_ID	year	recorder type	sample_ID	year	recorder type
HAFL_FS25	1815	inner_year	HAFL_FS17	1819	inner_year
HAFL_FS25	1845	dormant_fs	HAFL_FS17	1866	unknown_fs
HAFL_FS25	1860	dormant_fs	HAFL_FS17	1868	unknown_fs
HAFL_FS25	1868	early_fs	HAFL_FS17	1963	outer_year
HAFL_FS25	1874	dormant_fs	HAFL_FS8	1819	inner_year
HAFL_FS25	1890	outer_year	HAFL_FS8	1860	dormant_fs
HAFL_FS27	1828	inner_year	HAFL_FS8	1868	unknown_fs
HAFL_FS27	1845	dormant_fs	HAFL_FS8	1883	outer_year
HAFL_FS27	1860	dormant_fs	HAFL_FS23	1822	pith_year
HAFL_FS27	1868	unknown_fs	HAFL_FS23	1845	dormant_fs
HAFL_FS27	1873	outer_year	HAFL_FS23	1860	dormant_fs
HAFL_FS26	1831	inner_year	HAFL_FS23	1862	dormant_fs
HAFL_FS26	1845	dormant_fs	HAFL_FS23	1866	early_fs
HAFL_FS26	1860	dormant_fs	HAFL_FS23	1874	unknown_fs
HAFL_FS26	1868	middle_fs	HAFL_FS23	1890	outer_year
HAFL_FS26	1874	dormant_fs	HAFL_FS28	1822	inner_year
HAFL_FS26	1890	outer_year	HAFL_FS28	1845	dormant_fs
HAFL_FS30	1839	inner_year	HAFL_FS28	1860	dormant_fs
HAFL_FS30	1845	unknown_fs	HAFL_FS28	1868	middle_fs
HAFL_FS30	1860	dormant_fs	HAFL_FS28	1890	outer_year
HAFL_FS30	1868	early_fs	HAFL_FS52	1825	pith_year
HAFL_FS30	1891	dormant_fs	HAFL_FS52	1836	dormant_fs
HAFL_FS30	1918	outer_year	HAFL_FS52	1847	unknown_fs
HAFL_FS29	1850	pith_year	HAFL_FS52	1860	unknown_fs
HAFL_FS29	1868	dormant_fs	HAFL_FS52	1874	unknown_fs
HAFL_FS29	1891	dormant_fs	HAFL_FS52	1930	outer_year
HAFL_FS29	1902	unknown_fs	HAFL_FS24	1826	pith_year
HAFL_FS29	1914	unknown_fs	HAFL_FS24	1845	dormant_fs
HAFL_FS29	1929	unknown_fs	HAFL_FS24	1860	dormant_fs
HAFL_FS29	1944	unknown_fs	HAFL_FS24	1868	early_fs
HAFL_FS29	2019	bark_year	HAFL_FS24	1874	dormant_fs
HAFL_FS10	1913	inner_year	HAFL_FS24	1891	unknown_fs
HAFL_FS10	1937	unknown_fs	HAFL_FS24	1896	outer_year
HAFL_FS10	2019	bark_year			